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THE LIQUEFACTION OF GASES.

By Vaughan Cornish, M.Sc., F.C.S.

THE common liquids, such as water, rock oil, mercury, and so on, can be readily converted into gases; but many of the common gases, on the other hand, for instance oxygen, nitrogen, and hydrogen, can only be brought into the liquid condition by the use of special methods and powerful agencies. Temperature and pressure are the two factors on which it depends whether a body remains in the state of gas or assumes the liquid condition. Low temperature and high pressure are the conditions favourable to liquefaction.

The history of experiments on liquefaction of gases is mainly a record of devices for producing high pressure and low temperature. Sulphurous acid gas is condensed at the temperature of an ordinary freezing mixture, or at the pressure which can be obtained by a hand-worked piston in a tube or barrel. It had been prepared in the liquid state before the year 1800 A.D. Chlorine was condensed by Northmore in 1805, but his experiments attracted little attention till years later, when Faraday had made a speciality of the liquefaction of gases, and the attention of the scientific world was drawn to the subject. Then, as usually happens, forgotten records were found of earlier work on the same lines. The later, but independent, observation by Faraday (1823) of the liquefaction of chlorine is, however, the commencement of the systematic study of the subject. Faraday has the only kind of priority which is of real importance in scientific discovery—that, namely, of being the first to make the subject fruitful, and the first to make its importance generally understood. Faraday had been experimenting on the solid hydrate of chlorine which separates out in yellowish crystals when ice-cold water is saturated with chlorine gas. Sir Humphry Davy, to whom at that time Faraday acted as assistant, suggested that the crystals should be sealed up in a glass tube and heated. Davy gave at the time no reason for his suggestion, and Faraday himself did not know what to anticipate from the experiment. The crystals of the solid hydrate were placed at one end of a Λ-shaped glass tube, which was then closed by sealing up the glass in the blow-pipe flame. The crystals being warmed to 60° F., underwent no change, but at 100° F. "the substance fused, the tube became filled with a bright yellow atmosphere, and on examination was found to contain two fluid substances; the one (chlorine water), about three-fourths of the whole, was of a faint yellowish colour, having very much the appearance of water; the remaining fourth was a heavy bright yellow fluid, lying at the bottom of the former without any apparent tendency to mix with it." At 70° F. the pale portion congealed (*i.e.*, the hydrate separated out), although even at 32° F. the yellow portion did not solidify.

Heated up to 100° F., the yellow fluid appeared to boil, and again produced the bright coloured atmosphere. It was found that by heating to 100° F. the yellow liquid (fluid chlorine) could be distilled from the pale coloured liquid (chlorine water) so as to get them in different limbs of the bent tube. "If, when the fluids were separated, the tube was cut in the middle the parts flew asunder as if with an explosion, the whole of the yellow portion disappeared, and there was a powerful atmosphere of chlorine produced; the pale portion, on the contrary, remained, and when examined proved to be a weak solution of chlorine in water with a little muriatic acid."

The paper from which the above extracts are taken was read before the Royal Society by Sir Humphry Davy in 1823. In a note at the end of Faraday's paper, Davy says that "in desiring Mr. Faraday to expose the hydrate of chlorine to heat in a closed glass tube, it occurred to me that one of three things would happen: that it would become fluid as a hydrate; or that a decomposition of water would occur (forming hydrochloric acid); or that the chlorine would separate in a condensed state." Further on he remarks, "I cannot conclude this note without observing that the generation of elastic substances in close vessels, either with or without heat, offers much more powerful means of approximating molecules than those dependent upon the application of cold, whether natural or artificial, for as gases diminish only about $\frac{1}{480}$ in volume for every degree of Fahrenheit's scale, beginning at ordinary temperatures, a very slight condensation only can be produced by the most powerful freezing mixtures, not half as much as would result from the application of a strong flame to one part of a glass tube, the other part being of ordinary temperature, and when attempts are made to condense gases into fluids by sudden mechanical compression, the heat, instantly generated, presents a formidable obstacle to the success of the experiment, whereas in the compression resulting from their slow generation in close vessels, if the process be conducted with common precautions, there is no source of difficulty or danger, and it may easily be assisted by artificial cold, in cases where gases approach near to that point of compression and temperature at which they become vapours."

This "bent tube" method was successfully employed by Faraday in the liquefaction of a number of other gases.

In 1822, the year preceding Faraday's experiments on chlorine, Caignier de la Tour had examined the effects

produced by heating volatile liquids, such as alcohol or ether in closed tubes. In these experiments the liquid put into the tube was sufficient to fill it half-full, and the whole of the tube was heated; so that the conditions were different from those of Faraday's experiments. De la Tour observed that up to a certain temperature the liquid continued slowly to evaporate, the bulk of liquid diminishing, and the quantity of vapour increasing. This was the ordinary process of evaporation, which the eye can trace by observing that the position of the *meniscus* which separates the liquid and the vapour becomes lower and lower as the temperature increases.

When, however, a certain temperature is reached the *meniscus* suddenly disappears, and there no longer appears to be any liquid in the tube. On cooling the tube, the inverse change takes place with equal suddenness, a *meniscus* (the line of separation between liquid and vapour) suddenly appears, showing that on lowering the temperature a large amount of liquid is suddenly formed. De la Tour's experiments point to conclusions quite opposite to those of Davy, quoted above; since the "approximation of particles" brought about by pressure was more than counterbalanced by the repellant action of heat.

In 1845, in a second paper on Liquefaction of Gases, Faraday writes with a mastery of the subject which neither he nor Davy possessed in 1826. He says (*Phil. Trans.*, 1845, p. 155): "My hopes of success beyond that heretofore obtained depending more upon depression of temperature than on the pressure which I could employ in these tubes, I endeavoured to obtain a still greater degree of cold. There are, in fact, some results no pressure may be able to effect. Thus, solidification has not yet been conferred on a fluid (*i.e.*, a gas) by any degree of pressure. Again, that beautiful condition which Caignier de la Tour made known, and which comes on with liquids at a certain heat, may have its point of temperature for some of the bodies to be experimented with, as oxygen, hydrogen, nitrogen, &c., below that belonging to the bath of carbonic acid and ether, and in that case no pressure which any apparatus could bear would be able to bring them into the liquid or the solid state." The "bath of carbonic and ether" here referred to, was a device for obtaining a very low temperature, a kind of improved freezing mixture in fact. Thilorier and afterwards Natterer had constructed apparatus in which carbonic acid gas could be liquefied by pressure alone. When liquid carbonic acid is exposed to the air at the ordinary pressure, some of the liquid evaporates very rapidly, thereby chilling the lower layers of liquid to such an extent that they freeze, forming solid carbonic acid. If ether be mixed with this solid carbonic acid, and if the pressure be diminished by means of the air pump, the further cooling due to evaporation of the ether reduces the temperature to $-110°$ C. This extremely low temperature was employed in experiments by which Faraday endeavoured unsuccessfully to liquefy hydrogen, oxygen and nitrogen. Andrews employed the same means of producing cold, but used more powerful apparatus for compression. Although by combined cold and pressure the above-named gases were reduced to less than $\frac{1}{300}$ of their original volume no liquefaction took place. Andrews also conducted experiments upon the phenomenon observed by De la Tour, and showed that above the "critical temperature" of 31° C. the greatest pressure which he could bring to bear was not sufficient to liquefy carbonic acid, but that if the temperature were lowered the liquefaction took place at once.

In the later and successful experiments on the liquefaction of the "permanent" gases, such as nitrogen, oxygen, and hydrogen, the skill of the experimenter has been chiefly shown in the means devised for obtaining temperatures below the "critical point" of these gases. Pictet, of Geneva, who liquefied oxygen in 1877, relied for the production of a low temperature upon the well-known principle of latent heat of evaporation. The novelty in his application of this principle lay in the fact that he employed *two* evaporating substances—namely, sulphur-dioxide and carbonic acid. By the use of the doubly-acting pumps employed in refrigerating machinery (*vide* KNOWLEDGE, March, 1891, "Artificial Cold") liquid sulphur-dioxide can be obtained having a temperature of $-65°$ C. In Pictet's apparatus the cold liquid sulphur-dioxide is contained in an annular vessel, which forms a jacket round the tube in which carbonic acid is condensed by the action of another doubly-acting pump.

The liquid carbonic acid is reduced to a temperature of 65° C. by the cooling action of the "jacket," and, consequently, when the pump is reversed and used as an exhaust pump, the evaporation of the cooled liquid produces an extremely low temperature, and the vapour can again be condensed so as to form a liquid jacket round the oxygen tube, having a temperature of $-130°$ C. This tube of copper was made very strong to withstand pressure. The oxygen gas was passed into the tube direct from a strong iron retort in which it was evolved, and thus the pressure continued to rise as more and more oxygen entered the tube. At a pressure of about 500 atmospheres, the manometer remained stationary, showing that liquefaction had begun. The whole of the tube was at length filled with liquid oxygen, which was examined by opening a stopcock, when a jet of a lustrous liquid issued with great force from the tube, to be speedily dissipated by evaporation.

Cailletet, who worked independently at the same problem, first succeeded in liquefying oxygen on the very same day as Pictet. He employed simpler appliances, and worked on a different principle. He relied for obtaining his frigorific effect upon the *chaleur de détente*, or latent heat of expansion, of the gas with which he was working. The term "latent heat of expansion" is not a very good one, as gas is not cooled by merely expanding to fill a vacuum. When, however, a gas is allowed to expand in such a way as to do mechanical work, the gas loses in heat the thermal equivalent of the mechanical work performed. In Cailletet's experiments, the gas was contained over mercury in the capillary bore of an immensely strong glass tube. The tube was screwed into an hydraulic press worked by the leverage of a large wheel. The experimental glass tube was surrounded by a freezing mixture of which the temperature for the experiments was not lower than about $-30°$ C. So that in Cailletet's experiments no attempt was made to surround the gas with a very cold atmosphere. When the pressure attained 300 atmospheres the oxygen still remained in the gaseous condition, being much above the critical temperature, but, on suddenly withdrawing the constraining force from the piston of the press, the gas as suddenly expands, the elasticity or spring of the gas drives back the liquid and the piston, and the sudden mechanical effort of the gas is accompanied by a sudden chill sufficient to bring the temperature below the critical point. The liquefied oxygen was seen in the tube immediately the pressure was released. Cailletet's method had the advantage, that the process could be watched through the glass walls of the tube. On the other hand, Pictet's arrangement enabled him to prepare a larger quantity of the material, and to observe its behaviour when exposed freely to the atmosphere. As we have said, the liquefied oxygen was dissipated immediately by evaporation, so that no examination of its properties could be made. A fine mist, or

cloud, which formed when the oxygen evaporated may have been due to small particles of solid oxygen.

Experiments conducted since those of Cailletet and Pictet, fifteen years ago, have been designed so as to permit of the examination of the physical properties of the liquefied substances. This has been effected by obtaining such low temperatures of the material, and such a low temperature of its immediate surroundings, that the evaporation of the liquid (whether hydrogen, oxygen, or nitrogen) only takes place slowly under ordinary atmospheric pressure. In Cailletet's experiments, a liquid was obtained under low pressure, but the surroundings of the liquid were relatively warm, so that the substance could not long remain liquid. In Pictet's experiments the liquid could only be examined by removing it from the cold atmosphere. In the experiments conducted by Dr. K. Olszewski, the gas to be experimented on was contained in the innermost of four glass tubes placed one within the other. In the outermost tube was placed solid carbonic acid and ether. By placing this in connection with an air pump, the temperature of the neighbouring tubes was reduced to −100° C. This was the method for obtaining low temperatures, employed by Faraday in his later researches. Now comes a novelty. Ethylene gas, brought from a Natterer's cylinder, is led into the (second) inner tube. Here it is liquefied by low temperature, and under a considerable pressure. The two innermost tubes (into which the oxygen or hydrogen are presently to be brought) are now surrounded by a tube containing liquid ethylene at about −100° C. This liquid is protected from the warmth of the air by the outermost jacketing tube of carbonic acid ice. By the action of an air pump the pressure on the liquid ethylene is reduced to 10 mm. of mercury (about $\frac{1}{76}$th the ordinary atmospheric pressure); dry air at the same time is cautiously blown through the ethylene to prevent its evaporation from becoming violent. The gas (say oxygen) is now passed into the two innermost tubes. The intense cold produced by the evaporation of the liquid ethylene, the liquid being to begin with at about −100° C., liquefies the oxygen, which is under a considerable pressure. But one more device remains to be mentioned, the most singular of all in Dr. Olszewski's process. The *two* innermost tubes, as has been said, contain the liquefied oxygen. They are now both put into connection with the air pump, and the pressure is cautiously diminished. The liquid in both tubes begins to evaporate and is thereby chilled. Presently, the liquid in the outer tube begins to evaporate more quickly than that in the innermost one, owing to the fact that it is in contact with the (relatively) warm ethylene tube. The whole of the liquid in the outer tube consequently evaporates whilst there still remains a considerable portion of the liquid in the innermost tube. The temperature of the innermost tube has now sunk considerably lower than that of the liquid ethylene. Nitrogen can be frozen in this way. By diminishing the pressure on the solid nitrogen, and thereby causing evaporation, Olszewski obtained a temperature of −225° C., or less than 50° C. from the supposed absolute zero of temperature, that is to say, the point at which *all* the heat has been extracted from a body.

The exceedingly cold liquid contained in the innermost tube is protected from the relatively warm ethylene by the non-conducting layer of rarefied gas in the intermediate tube. Consequently, the substance remains liquid at atmospheric pressure, or even at lower pressure for a space of time (five to fifteen minutes) sufficient to allow of an examination of some of the important physical properties. Thus the specific gravity is determined by measuring the height at which the liquid stands in the tube, hence deducing the volume of the liquid; then collecting the gas after evaporation, and measuring its volume. The weight of a given volume of *gas* is, of course, well known. This is necessarily equal to the weight of the liquid before evaporation. Hence we know the weight of the liquid in the tube. Its volume having been ascertained in the way described, the specific gravity is readily calculated under atmospheric pressure; it is found that—

	Melts at.	Boils at.	Critical Temp.
Oxygen ...	—	−164°	−118·8° C.
			Sp. gr. of liquid.
			1·124 at −181·4° C.
Nitrogen ...	−214°	−194·4°	−146° C.
			Sp. gr. of liquid.
			·885 at −194° C.

Hydrogen at −213° C. liquefied under a pressure of 190 atmospheres; with Pictet's temperature of 140° C. a pressure of 650 atmospheres was required. The temperatures recorded in the above observations were all registered with a hydrogen thermometer. The critical point of hydrogen is −220° C.

BEE PARASITES.—II.

By E. A. Butler.

(*Continued from page* 128.)

THE economy of the solitary bees is, of course, quite unlike that of the social species, and it will be anticipated that the parasitism from which they suffer is also of a different type. In solitary bees the species consist only of males and females, and hence all the labour necessary for the rearing of the young falls upon the latter sex. They excavate tunnels in sandy or clayey banks, posts, trees, or wherever else the habits of the particular species dictate, and in these burrows cells are arranged, each intended for a single grub; the eggs are deposited upon a previously provided stock of food, consisting chiefly of the pollen of flowers, often made up with a little honey into small pellets. As the larva, like that of the hive bee, is a footless maggot, quite unable to leave the cell in which it is cradled, and is not continuously tended by its parent, the amount of food provided must be such as will last it during the whole of its larval life. This quantity is not large, considerably less in fact than might have been expected, but its amount has, in some inscrutable way, to be correctly estimated by the mother bee. A slight deficiency in the amount would probably not be fatal to the life of the grub, but would rather result in dwarfing the size of the insect produced; hence the physique of the race would seem to depend in great measure upon the accuracy of the mother's estimate of the amount of food her offspring will require.

When the pea-like globule of bee food has been provided, the egg laid, and the cell closed, the mother's work, so far as concerns that particular member of her family, is done; her other toils consist simply of repetitions of these operations on behalf of the remainder of the brood. Many journeys abroad and much diligent work therefore devolve upon her before she has fully discharged the function she has to perform in the world; and as the collection of pollen and the construction of the burrow and its cells are dependent to a great extent upon weather, since bees have a great dislike to cold and windy or damp days, the completion of the important task of laying the foundation for next year's race will often, in the uncertainties of our English climate, become a rather protracted business. As so much outdoor work is involved, it is clear that the burrows will often be left by the solitary owner unprotected,

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so that abundant opportunities are afforded to parasitic insects of various kinds to effect a surreptitious entrance. Disguise therefore would, in such cases, serve no good purpose, and accordingly we find that the parasites of the solitary bees do not mimic their hosts, but are often as unlike them as could well be imagined; they seem, in fact, in some cases to have gone to the other extreme of casting caution to the winds, and boldly advertising themselves in the brightest of colours. For obvious economic reasons the diameter of the burrow is usually not much more than sufficient to admit of the easy passage of the bees along it. This, no doubt, has some effect in determining what insects shall be parasitic upon any given species of bee, for it evidently fixes a maximum limit of size for the invader, none being able to gain entrance whose dimensions are too portly. Moreover, as in the majority of cases the stranger will be reared either upon the food stored up for the young bee or upon the young bee itself, we may expect that for this reason also the size of the parasite will not exceed that of its host.

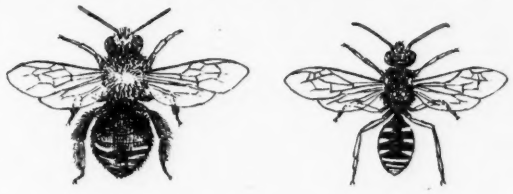
Our British insect fauna would yield many illustrations of the above general principles, for there is probably no species of industrious bee that is not subject to parasitism of some sort or other. A few of the most remarkable of these may be given, and, as in our former paper, we will first consider the parasitism of bee upon bee. There is an insect commonly found burrowing into banks which is no doubt often mistaken for a humble bee. The female is a stout-bodied, densely hairy, black creature, with blunt round body, and thick reddish brushes on its hind legs; the male is altogether different, being yellowish brown, with long shaggy tufts of hairs on its feet. Notwithstanding that it has somewhat the appearance of a *Bombus*, it is not a social insect, though it is gregarious; by which is meant, that the species does not consist of large numbers of individuals of three sexes inhabiting the same nest, but of pairs of individuals of two sexes not living in the same nest, but each female constructing a separate burrow for her own young, though in close proximity to those of her neighbours. They may be distinguished from the social humble bees by the structure of the hind legs, on which no "corbicula" is found, such as a *Bombus* would have. This bee is called *Anthophora pilipes*, and it is one of the earliest to appear in spring time. It builds, or rather excavates, in steep bare banks or other exposures of earth, and will often take advantage of artificial accumulations of this kind. Thus I once saw a large colony which had formed their burrows in the walls of a thatched shed built up of turf, clods of earth, and dried mud; the bees were flying in swarms round the building, busily engaged in constructing their cells or provisioning their nests.

This insect has associated with it an extremely handsome parasite called *Melecta armata*, which is a bee of an intensely black colour, with ash-coloured hairs on the head and thorax, and beautiful snow-white tufts adorning in elegant contrast the sides of its otherwise jet black abdomen. It has a pointed body which is nearly bare, save for the snowy patches, and, of course, its legs do not carry brushes for the conveyance of pollen; in fact, unlike most bees, parasitic or otherwise, it appears to visit flowers very seldom. From this description it will be seen that the parasite is quite unlike its host, both in shape and adornment. There is great difficulty in accurately determining the details of the life-history of many of these bees, as will be evident from the fact that their nurseries are situated several inches below ground at the ends of narrow and dark passages, and that all the incidents of their domestic history are transacted in these retreats, remote from the curious eye of man; but it is pretty certain that in these cases of the association of bee with bee, the egg of the parasite is laid upon the store of food provided by the industrious bee, and the larva of the parasite, instead of that of the host, is nourished upon this store. Thus, from the habit of laying their eggs in other bees' nests, and leaving their young to be fed with materials furnished by a foster parent, these and other bees with similar habits are often called cuckoo-bees. It is a curious fact that there is another species of *Anthophora* very closely allied to the above insect, so closely indeed, that it needs a keen scrutiny to detect the points of difference, and that this too has a *Melecta* parasitic upon it, which again is specifically distinct from the other, though equally closely allied. Hence it would appear that the association of these bees is of long standing, and that whatever causes have produced the differences between the two hosts, have in like manner affected the parasites, though not quite to the same extent.

We have a large genus of elegant bees with bare legs and bodies, which latter are very prettily variegated with bands of brilliant yellow, reddish, and black; hence they are often called wasp bees. They are, however, true bees, and are not vindictive like the wasps, for, though the females are possessed of stings, they cannot do much damage with them. They have the additional advantage of exhaling a fragrant odour. The genus is called *Nomada*, the name being given in consequence of their roving habits; for they appear to be entirely parasitic, being in fact structurally incapacitated for the collection of pollen. Very little is definitely known of their economy, but it would appear that their eggs are laid in the nests of sober-coloured industrious bees, especially those of the large genus *Andrena*, and it has been thought that they are laid before those of the rightful owner, so that, when the latter finds the store of food she has accumulated appropriated by a stranger, she deserts the cell, and forms another, leaving the intruder in undisputed possession. Sometimes two eggs are provided for a single cell, in which case one or both of the resulting bees is often smaller than usual. These parasitic bees must, in fact, often be driven to considerable straits in their endeavours to make a fair provision for their progeny, being so entirely dependent upon charity; visits to many a burrow may be necessary before a cell can be found with a sufficient store of pollen already accumulated, and after all the egg may have to be laid in an insufficiently provisioned cell, so that, in return for their shiftless habits, they have to run the risk of great variations in size, some being much dwarfed by a deficiency of food. As a compensation for these risks, they are spared an immense amount of labour, especially in the excavation of burrows and the collection of pollen. The hollowing out of a main tunnel to the depth of six inches or a foot, with short branch tunnels opening out of it, and all by the successive snipping off of fragments of earth with the jaws, and their conveyance outside, represents for a small insect a great deal of hard labour. And then the search for suitable wild flowers, growing within reasonable distance of the nest, and the collection from them of pollen to be worked up successively into pellets, one for each cell, involves a great many journeys and a considerable expenditure of time, which must often tax the energies of the industrious bees to the utmost. From all these toils the *Nomadæ* are exempt, unless indeed the closing up of the cells after they have laid their eggs devolves upon them as some have supposed; notwithstanding the risks therefore, they must, on the whole, find the practice of parasitism pay, or they would have become extinct ere this.

The *Nomadæ* are not interfered with by their hosts,

which, on the contrary, calmly acquiesce in the appropriation which renders much of their labour abortive; hence the parasites fly freely about amongst them, and pass in and out of the burrows without opposition. An interesting observation of Mr. F. Smith may be quoted in point. The host in this case was a brownish stout-bodied bee, the female of which (Fig. 3, A) is a good deal like an *Anthophora*



A B

Fig. 3.—A. Solitary bee (*Eucera longicornis*, female). B. Its parasite (*Nomada sexfasciata*), slightly magnified.

in shape, while the male may be easily distinguished from all other British bees by its enormously long antennæ, which are nearly as long as the body, whence its name *Eucera longicornis*, both parts of which refer to this feature; when freshly out it is a handsome insect with rich brown hairs on its thorax, but it soon fades on exposure to the sun and becomes weatherworn, old specimens appearing with dirty grey thorax and ragged wing-edges. The *Nomada* parasitic upon this is one of the largest and finest of the genus; it is called *N. sexfasciata* (Fig. 3, B), in reference to the six yellow adornments of its abdomen, which consist of three bands and three pairs of spots. Mr. F. Smith says that, whilst watching a colony of *Eucera*, the males of which were sportively flying round in circles, while the females were intent upon their maternal duties, returning every now and then heavily laden from their expeditions, he saw the parasites sometimes enter the burrows. Sometimes a laden female would return to its burrow just after a *Nomada* had entered it. On discovering the presence of the intruder she did not give battle, though much the stouter and heavier insect, but would simply retreat, fly off to a little distance, and wait patiently till the parasite issued from the burrow, when she would return to deposit her load. At a later season he unearthed some of the cells, and found the young parasites in them, two in each cell. The bees of this genus, *Nomada*, have not got their parasitism so definitely settled as those of the former genus *Melecta*; some of them are attached to a single species of industrious bee, but others are less particular, and depend upon a variety of hosts. Moreover, they do not, as a genus, confine themselves to a single genus of hosts, but divide their attentions amongst several that are of similar habits.

In the leaf-cutter bees we have a very peculiar and distinct set of insects, and, as might be expected, their parasites are equally distinct. The hosts line the cells they construct for their young with fragments of the leaves of shrubs, and everyone has probably noticed the appearance the leaves of rose-bushes present in gardens when they have been mutilated by these insects for this purpose. Semi-circular pieces are seen to have been cleanly cut out from the sides of the leaf; several such cuttings being often made from the same leaf when it is large enough. The bees themselves are not so often noticed; they belong to the genus *Megachile*, and are remarkable, not only for the leaf-cutting habit, but also because they have the whole of the under surface of the abdomen densely covered with hairs, which they use as their pollen-collecting apparatus. After visits to flowers, this part of the body may be seen to be heavily laden with the precious grains. The construction and furnishing of the cells is quite a work of art. A tunnel is first excavated to a length sufficient to accommodate perhaps half a dozen or more cells; the cells themselves (Fig. 4), which are composed entirely of leaves, are fitted into this, and placed one after the other along its length. An oval leaf fragment being placed so as to cover the end and a little of the sides of this tunnel, a number of semi-circular, neatly cut fragments are next placed round the sides in regular order and laid close, one upon another, each partially overlapping its neighbour, thus making a lining to the tunnel of several layers thick; the number of layers appears to depend upon the nature of the material in which the tunnel is excavated, and its condition as regards moisture, &c.; a specimen now before me has four such layers. A mass of mixed honey and pollen is now introduced, an egg is laid, and then some *circular* pieces of leaves brought to cover up the opening, just in the same way as the housewife puts a layer of paper over the jam in the recently filled jar; the specimen above mentioned has also four of these. A second cell is then built up in a similar way at the end of this, and so on till the whole set is complete: the whole tunnel is thus lined with leaves, and there are at regular intervals cross partitions, which are the tops and bottoms of the cells, and the leaves serve to protect the food from contamination by the walls of the tunnel, as well as to prevent loss of its more liquid component by soakage. When the larva has devoured the food, it is full grown; it then forms an oval lining of silk in the cylindrical cell, taking care to shut in the excrement which has accumulated during its larval life, between the walls of this silken lining and the outer leafy hangings of the cell. Within this cocoon it becomes a pupa.

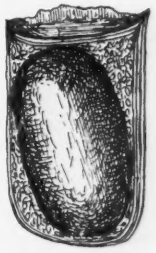


Fig. 4.—Section of cell of leaf-cutter bee (*Megachile*), with cocoon. Magnified 2 diameters.

These leaf-cutters are subject to the parasitism of a genus of cuckoo-bees called *Coelioxys*, which are black, almost hairless, cruel-looking insects, with pointed abdomen. They present a great contrast to our last illustrations, the *Nomadæ*, for instead of the gay colours, graceful proportions, and fragrance which distinguish that genus, they exhibit a sombre and funereal appearance and a less elegant form, and give out a disagreeable odour, which, no doubt, helps to secure them from attack. It is evident that they must keep a constant watch on the doings of their hosts, in order that they may introduce the egg just in the nick of time, after the cell has been sufficiently provisioned, and before the first layer of its many-plated lid has been put on, and hence they are usually to be found in the neighbourhood of the burrows of the leaf-cutters.

(*To be continued.*)

ON THE CAUSE OF EARTHQUAKES.

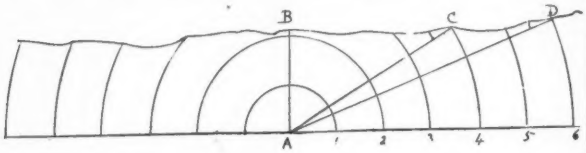
By the Rev. H. N. Hutchinson, B.A., F.G.S.

RECENT investigations have shown that *terra firma* is a phrase indicating a condition of things which, scientifically, has no existence. The crust of the earth is in a state of constant movement. Geologists have begun to study systematically the phenomena of earth-movements of all kinds, and some of the results are such as cannot fail to interest even the general reader. We all have a stake in the condition of our

planet. However, those who live in a region seldom visited by earthquakes are apt to overlook the importance of the subject. "Out of sight is out of mind," but as new methods of investigating and recording earth-tremors, or throbs, are invented, these things are brought more prominently before us. Seismology, or the study of earthquakes, has lately been making great advances, and has revealed slight movements, the existence of which was previously unsuspected.

In view of these additions to our knowledge of an important branch of natural science, we propose to say a few words on earthquakes and earth-tremors of all kinds, dividing the subject under three heads: (1) *What they are*, (2) *What they do*, and (3) *How they are caused*.

An earthquake has been defined by a high authority, the late Mr. Louis Mallet, as a wave or series of waves, of elastic compression, through the crust of the earth, in any direction, and from any given "centre of impulse." To understand this definition, think of what takes place when a stone is thrown into a pool. A disturbance is made at the place where the stone strikes the water; that spot corresponds to the "centre of impulse," the particles there communicating the movement to those next them, and these in their turn to others, and so on. In this way a series of concentric waves is produced, which get fainter and fainter, until finally they reach the edge of the pool. This is very similar to what happens when a subterranean disturbance gives a blow to the earth's crust, and a series of earthquake waves is produced from some seismic centre. But, in both cases, the waves really travel in spherical shells. (See figure.) These waves, be it remembered, are due to wave-motion, like waves of sound, and are by no means waves of translation. Each particle of earth merely moves as the ears of corn move in a field when they bend to the wind, and produce waves which travel across the field before the wind. It is clear that the undulatory movements due to an earthquake shock must strike the surface of the earth at different angles, according to the distance of the seismic centre. Thus, a person who might happen at the time to be standing on the spot B in a vertical line above such a centre would feel an up and down movement, and a block of stone lying near him might be thrown straight up in the air; but if the person were some miles away from this spot, it is evident that the waves coming sideways would strike him to the ground he stands on obliquely; and "the angle of emergence" becomes less and less the further we recede from the spot lying just over such a centre. Now, it is possible, by observing the effects of earthquakes on buildings, to determine the direction in which the shock arrived, and to calculate the "angle of emergence." This is done chiefly by studying the cracks produced in buildings, and making allowance for the circumstances of each case. If, then, this angle can be ascertained for two places, and the distance between them is known, a triangle is obtained, the base of which is known, and the angles at the base; hence it is easy to calculate the depth of the centre of disturbance. Such calculations have been made in several cases, and the results arrived at are of considerable interest; for they tell us that in no case is the seismic centre at a greater depth than thirty miles. In some cases the earthquake has been found to have originated at a much less depth. If these results are trustworthy, as there is reason to think they are, the conclusion is that earthquake phenomena are not connected with the deeper-seated portions of the mass of the globe, but with those superficial portions commonly included in the earth's crust; and probably with the stratified series of rocks and their associated volcanic and plutonic rocks, rather than with the original mass which we believe to have solidified from a molten and highly-heated state.



A, Centre of impulse; 1, 2, 3, 4, 5, 6, Waves; A C B, A D B, Angles of emergence.

Earthquake waves can be measured, and it is found that they are quite small, having amplitude of perhaps only a few inches. The crust of the earth vibrating in response to a seismic blow may be compared to a big bell resounding after its inner surface has been struck by the clapper. In either case the amplitude of the vibrations is capable of measurement, but the undulatory movements are not visible as we look at a sounding bell, though a marble suspended by a string and allowed to touch the bell's rim would at once demonstrate their existence by oscillating to and fro. The rebounding marble aptly illustrates the case of a block of stone being hurled up into the air by an earthquake wave. It is known that sound travels with different velocities through different substances, according to their compactness and elasticity. Hence we need not be surprised to learn that earthquake shocks have sometimes been heard twice; once through the solid rock, and so up to the ear, and again through the air which transmits the waves more slowly. Mr. Mallet made some interesting experiments on the velocity of transmission of waves due to a blow, through different substances.

In *air* the mean velocity of sound-waves is 1138 feet per second, but it varies with the atmospheric temperature and pressure—in water 4692 feet, and in a bar of iron 11,040 feet per second. The movements of the ground during an earthquake are of a complicated character. In addition to the two kinds of movement which have generally been observed—namely, the upward shock, and the long undulations, spreading in all directions, like marine waves—most authorities have added a rotating or gyratory movement. This causes a twisting of the ground, which has not only been seen but felt. Humboldt says that in Chili three great palm trees were seen to twist round one another like willow-wands, after each had swept a small space round its trunk. Pinnacles of buildings have likewise been found to be twisted. The noise accompanying an earthquake often resembles that of an explosion. Since the velocity is affected by the hardness of the rocks, it follows that strata containing any hollows partly break and check the waves, as stakes driven into a shore break the force of sea-waves in a storm. Hence we find that the early Greeks and Romans dug wells to fortify some of their cities, and prevent their complete destruction. In South America the natives have long ago adopted the same plan. Springs and natural underground passages for this reason afford considerable protection to cities which are liable to be visited by earthquakes.

Much has of late years been learned regarding seismic disturbances by taking observations which give the direction of the wave or waves, its velocity (obtained from the exact time at which it reached different places), and the "angle of emergence" as previously explained. The results are mapped out, and thus an "earthquake chart" is made, somewhat resembling the "weather charts" published daily in the *Times* newspaper. This done, it is invariably found that the greatest destruction is effected

directly over the "centre of impulse," and that the waves run roughly in circles or in ellipses from such a central spot. But the shapes as mapped out are often very irregular. This will be due to the nature of the surface of the ground and of the rocks below. It appears that in mountainous countries, like Switzerland and the Pyrenees, the great undulations are propagated in the direction of the valleys. In striking against the tilted strata at the bases of mountain masses they behave like waves of a river which dash against a bank, breaking up and changing their courses, and running along at the foot of the heights in the same direction as the stream of the valley. Earthquakes, though violent in their effects, are fortunately of very short duration. The great Calabrian earthquake lasted barely ten seconds!

We must now pass on to our second question, and consider the *effects* of earthquakes. First, they make many noises, variously described as resembling explosions of mines, distant artillery, peals of thunder, roar of cataracts, &c. Sometimes the shocks are felt before they are heard. Take the famous Lisbon earthquake of 1755. Towns in Portugal were overthrown, and places even in Morocco suffered considerable damage. The undulations extended over one-twelfth of the earth's surface! Thousands of persons were killed in Lisbon, and the sea was greatly disturbed. In England, lakes and pools oscillated to and fro like water in a basin suddenly tilted. Even Iceland was affected. The sea rose in a great wave round the coasts of Britain, and ten hours after, the sea round the West Indies was greatly disturbed! Shocks occurred for some months afterwards.

Sometimes, as at Jamaica in 1692, the sea-wave does more damage than the land-wave. At Port Royal, 2500 houses were covered with water to a depth of 33 feet. It is interesting to note the behaviour of animals before an earthquake. They seem to be able to detect slight tremors of the ground which we ourselves do not notice, and which precede earthquakes. Rats and mice leave their holes. The ground is frequently rent asunder, and sometimes permanent changes of level take place.

But it is not of the effects of seismic disturbances that we wish now to speak; they are well known, and have been repeatedly described. Their nature and origin, though less clearly understood, afford more interesting matter for a brief paper such as the present. Let us therefore pass on at once to consider our third question: how earthquakes are caused. It has been shown in Switzerland that they are more frequent at night than during the daytime; and during winter than during summer. Facts of this nature seem to indicate that the contraction of rock masses, due to a lowering of temperature, such as absence of sunlight would involve, is intimately connected with whatever causes are at work in the earth's crust to produce earthquakes. Such contraction might produce dislocations in the rocks, and these would set up vibrations. Again, by burying charges of gunpowder and guncotton, and exploding them, Prof. Milne has succeeded in producing, on a small scale, phenomena closely resembling seismic disturbances. Experiments of this nature lead to the conclusion that some sudden blow, or impact, is the most frequent cause of earthquakes. But we must be careful not to assume that only one cause exists, and that all earthquakes are due to the same cause. Evidently this is not the case. During volcanic eruptions, and also previous to an eruption, the ground trembles, and rumblings are heard, as of earthquakes. In Switzerland, avalanches of snow in slipping down a mountain side cause slight earth-tremors. The occasional falling down of great masses of rock produces similar effects.

The distribution of earthquakes helps to throw light on this difficult and, as yet, rather obscure subject. Thus they are found to be more frequent in mountainous regions than in flat, low countries. They have a connection also with volcanic regions, but rather an indirect than a direct one; for it is clear that earthquakes in general are not due to volcanoes or volcanic phenomena. Some geologists wrongly considered that all earthquakes were to be regarded as incomplete or unsuccessful attempts to establish a volcano. In other words, they are not caused by the struggles and efforts at escape made by superheated steam retained at high pressure below the surface of the earth. Steam undoubtedly is the power chiefly concerned in the production of volcanoes and of volcanic phenomena. But although earthquakes are concomitants of volcanic action, they are not to be attributed generally to the same causes. Volcanoes are associated with great mountain chains, because it is only along these lines of weakness in the earth's crust—where the strata has been contorted, crumpled, folded, and cracked, over and over again, on a stupendous scale—that the masses of heated rock below the surface, charged as they are with superheated steam at enormous pressure, can find relief and come up to the surface.

By burying telephones and microphones in the earth, it has been found that slight noises and tremors which would otherwise never be noticed—unless by animals—can be detected. Transient shiverings of the earth's crust are thus found to be very frequent. Even in Britain we have a soil subject to storms of microscopic earthquakes which, in other countries, would be the forerunners of actual earthquakes. Wherever these little earthquakes occur the earth sends forth a medley of confused sounds—crackings and snappings—probably caused by the rocks creeping toward relief from the strains which urge them to change their position. Thus we begin to realize that the world is quivering like a mass of jelly! It is hardly too much to say that this method of observation has enabled us in part to perceive the constant working of the great telluric machinery which continually builds our lands! Between these tiny movements and those which cause ordinary earthquakes there is only a difference of degree. They are essentially of the same nature. By means of delicate spirit levels, the bubbles of which move very easily, certain other movements, called "earth pulsations," have been detected by Prof. Milne. All these phenomena must be taken into account if we wish to find a satisfactory explanation. Mr. Mallet submitted for consideration the following possible causes:—(1) The sudden formation of steam by water coming in contact with highly-heated rock; (2) The escape of steam at a high pressure through fissures in the rocks and its condensation on reaching the sea; (3) Volcanic explosions; (4) Great fractures and dislocations in the earth's crust, suddenly produced by pressure or contraction, in any direction. The first three of these suggestions are not sufficient to account for earthquakes which occur outside volcanic regions; the last one seems to supply what is wanted, namely, an explanation which connects earthquake phenomena with those movements of the crust of the earth which (as shown in a previous article)* raise our continents, elevate our mountain chains, and afford means of escape for highly-heated rocky matter and associated steam from those deeply buried regions where the internal and external portions of the earth react upon each other. In mountain building and the folding of strata we may look for the main cause of earthquakes. It is titanic work, and must necessarily involve innumerable

* Knowledge for June, 1891.

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snappings and much slipping of rocks past each other. Probably the slipping movements —the existence of which is abundantly proved by the numerous "faults" so familiar to geologists—took place gradually, that is, only a few inches at one time; so that a single fracture may have given rise to hundreds, or even thousands, of earthquakes. There is in mountain building a chance for many slight shocks with but a small amount of motion. In the formation of such folds as those composing Mont Blanc the tremors may have been numbered by the million. If earthquakes are associated with the raising up of mountains, who shall say that they are of no use?

PLANETARY NEBULÆ.

By MISS A. M. CLERKE, *Authoress of "A Popular History of Astronomy during the Nineteenth Century," and "The System of the Stars."*

THE question "What is a Nebula?" put by our editor to himself and his readers in the last number of KNOWLEDGE, must have brought home to many minds, with startling distinctness, the extreme difficulty of forming a rational conception as to the real physical status of cosmical clouds and cloudlets. They lie indeed so far beyond the range of our immediate experience, that observations of them are apt to become more perplexing the more they are rendered minute and detailed. Speculations regarding their nature have hitherto been sternly checked by the collection and verification of facts. They flourish only under the shelter of a certain amount of vague generality, while the test-questions which every theory worthy of the name must sooner or later put to experience, have so far uniformly been answered in the negative. Added knowledge has not, accordingly, in this direction, brought clearer understanding. In the registration, for instance, especially by photographic means, of lines in the nebular spectrum, and in the accurate determination of their places, much has of late been done; but their interpretation remains as backward as ever. Nebular chemistry has scarcely yet entered upon the path of progress; what it has done hitherto has been mostly to put a veto upon mistaken identifications, leaving affirmative propositions to the future. It is acquainted with but one terrestrial element; almost the only positive assertion warranted by the evidence at its command is that hydrogen is extensively present in the "fire-mist" of the skies, and present in a state of high molecular agitation. This indeed is a most important piece of information; the possibility of obtaining it proves nebular to be separated by no impassable gulf from terrestrial conditions, and gives good hope, accordingly, of eventual advance along this line of investigation.

A peculiar interest, then, attaches to the detection and demonstration of structural resemblances between nebulæ and other heavenly bodies. Mr. Ranyard pointed out some few years ago the faithful imitation of solar prominence-forms by some of the gigantic outgrowths of shining fluid from the trapezium of stars in Orion; and the resemblance is accentuated by the undoubted presence in the nebula of the solar element helium. Cometary analogies, on the other hand, are backed by no well-ascertained chemical coincidences; yet they are prevalent and remarkable. The wings and wisps, the tails, rays, and trains, the complicated varieties of tenuous veils and envelopes that develop together or in succession during the rapid sweep of a great comet round the sun, are reproduced over and over again, with endless modifications, in the "lucid matter" of remote space. But they are stereotyped in being reproduced. Forms that might well be concluded to be purely transitional, and that are in the highest degree suggestive of evanescence, are nevertheless maintained, decade after decade, without appreciable modification. Processes of change are no doubt meanwhile progressing ceaselessly, but on so vast a scale in space, and at so leisurely a rate in time, as completely to baffle human observations during the short span available for them. Hints as to their character may, however, in the course of years, be gathered by studying the distribution of matter brought about by their action. The curious discovery, moreover, has of late been made that data on this subject may differ widely, and lead to widely different conclusions, according as visual or photographic means are employed to procure them. This incongruity between effects to the eye and impressions on the sensitive plate first became apparent in M. Trépied's photograph of the annular nebula in Lyra (KNOWLEDGE, vol. xiii., p. 253); it has now been found to characterize two well-known planetaries, and may be inferred to belong, more or less, to all members of the same class.

The distinction between annular and planetary nebulæ has been to a great extent abolished by the use of improved optical appliances. Each kind seems to be made up of three essential parts; a faintly shining disc—or globe projected into a disc—a ring-like condensation near its outer margin, and a central nucleus, presenting the appearance of a star. This last feature is often *seen* only with extreme difficulty, but there is reason to believe that it always exists. Mr. Burnham, who has measured a large number of these objects with the Lick 36-inch, for the purpose of providing a standard of comparison for the determination of their possible future movements, goes so far as to suggest that the presence of a central star should be regarded as the criterion of classification for planetary nebulæ.* He adds:—"Various powers have been used in studying these central stars, and particularly the brighter ones. In no instance has any one of these stars presented under any power any peculiar appearance. So far as it can be determined in this way, they all appear to be true stars, differing in no sense from the comparison stars. Many of the nights on which these measures were made were of the best quality, and any nebulous or other unusual appearance should have been apparent if it really exists."

Nevertheless, photography has a very different story to tell, as we shall see presently.

A small bluish disc observed by the elder Herschel near the star ν Aquarii was estimated by his son as equal in light to a 6·7 magnitude star, and took its place as No. 4628 in his General Catalogue. It is No. 7009 of Dreyer's New General Catalogue. With the Parsonstown reflector, in 1850, the surface of the nebula appeared tolerably uniform; it was interrupted by no certifiable perforation, and emblazoned by no central star. It gave the effect, however, in 1873, not of strict ellipticity, but of being made up of two overlapping circular segments.† It was seen, besides, to possess a pair of singular appendages like the "ansæ" of the ringed planet in our own system; and Mr. Lassell's first impression of the object at Malta was that of "a sky-blue likeness of Saturn." An interior ring, too, measuring 26″ by 16½″, and projected upon a hazy background, was plainly visible; while a small star marked the middle-point of the entire formation. Yet the great Vienna refractor failed, in 1883, to display the star to Vogel, although a power of 1500 brought out complexities of internal nebulous arrangement strongly suggestive of an essentially spiral structure. The results of Professor

* *Monthly Notices*, vol. lii., p. 31.
† *Trans. R. Dublin Society*, vol. ii., p. 159.

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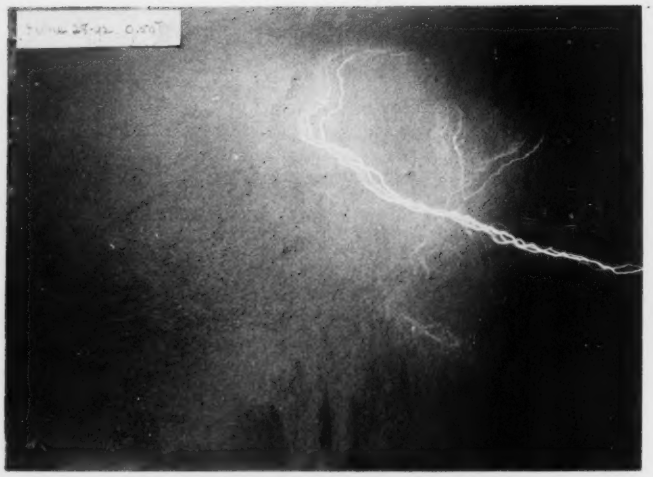
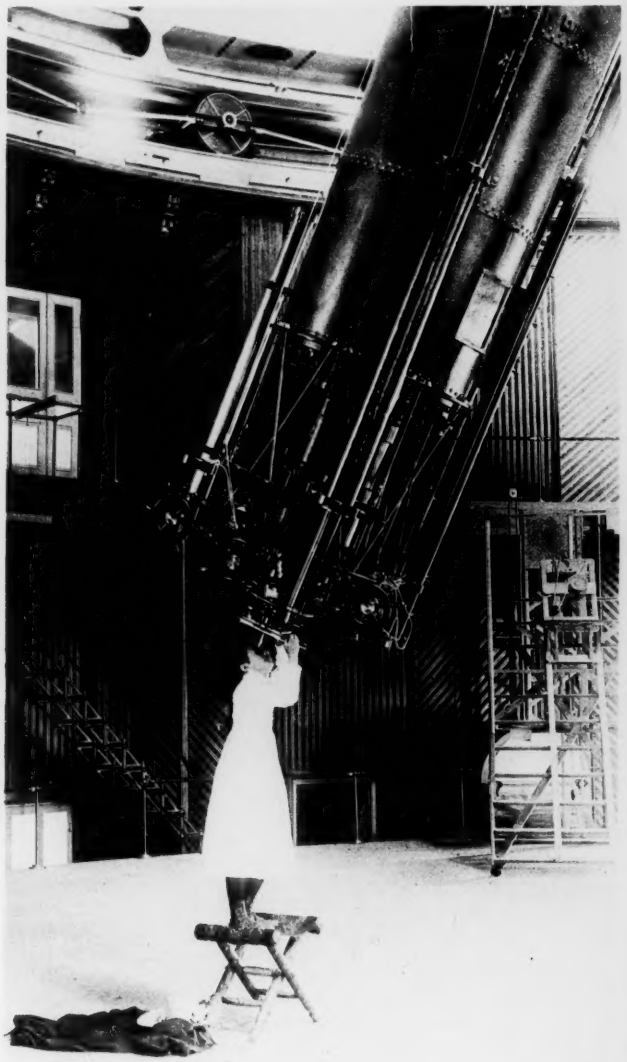


Photograph of Lightning Flashes, taken by Mr. F. H. GLEW on the 28th June, 1892, with a lens mounted on the hammer of an electric bell, vibrating about nine times per second.

Photograph taken during a heavy thunderstorm at Newcastle on the 17th July, 1891, at 10.15 p.m., by Mr. W. F. DUNN, and believed by him to be a photograph of Ball Lightning.

The nearest house to the Lick Observatory, from a photograph taken by Mr. S. W. BURNHAM.



The eye-piece end of the great Lick 36in. Refractor, from a photograph by Mr. S. W. BURNHAM. The camp-stool is standing on the movable floor of the Observatory, which can be raised or lowered by hydraulic machinery.

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Holden's scrutiny of the "Saturn planetary" in August, 1888,* with the Lick 30-inch, deserve careful consideration. He found it to consist mainly of a star, or nebulous nucleus, surrounded by an elliptical ring lying upon an oval shield much less vividly luminous, while two exterior nebulous patches, situated nearly in the prolongation of the major axis of the ellipse, seemed to be connected with it by faint gleams of phosphorescent illumination. These represented the "ansæ" of earlier observations, and indeed their detachment from the main body had been suspected at Parsonstown in 1852, and pretty well made out in 1862. Possibly, they are embryo-satellites of the nebulous system they are still partially attached to; nor can their position relative to its longest diameter be easily regarded as accidental. We are irresistibly led, on the contrary, to trace an analogy between them and the nebulous effusions from the extremities of the major axis of the annular nebula in Lyra, and to infer in both cases the genuinely oval shape of the objects presented to our view. For why should a mere perspective effect be emphasized in any way by physical configuration?

The nebula in Aquarius was perceived by Professor Holden as of a pale blue, but its stellar nucleus as white; the difference of colour being in fact so decided as to require a change of focal adjustment in passing from one to the other. The interior arrangements of the nebula were evidently extremely intricate. The central oval, instead of being bounded by a smooth curve, "looked like an elastic link which had been warped." A sudden failure of light in the glimmering ring near the southern extremity of its minor axis enhanced the effect of distortion; but a helical form, though suggested, could not clearly be made out.

A strikingly similar object is situated in the constellation Andromeda (N.G.C. 7662). Imperfectly seen at first as a uniform, greenish-blue disc, an interior vacuity detected at Parsonstown betrayed its true nature to be rather annular than simply planetary. Nor is the ring it includes by any means symmetrically shaped. Lassell considered it to be bi-annular; Professor Vogel was impressed with the warped and twisted aspect of what may conceivably prove to be a multiple combination of rings thrown off in various planes. Closely-wound spiral branches, and a central star, were perceived with the Rosse reflector; but the object appeared starless to Dr. Struve in 1847, as well as to Searle, using the Harvard 15-inch refractor, in 1866. Lassell gave 32″ by 28″ as the dimensions of the outer ellipse; and saw the "central star" in the guise of a minute planetary disc, tinged with blue. To Vogel, however, it was entirely invisible, in spite of his best efforts for its discovery. Yet he noticed the sparkling appearance which had misled Father Secchi into the belief that he held in the field of his equatorial a "magnificent ring of stars."† For the "horse-shoe of star-dust" in Andromeda, like its *alter ego* in Aquarius, gives the usual gaseous spectrum of planetaries, which is now known to include, as a fourth visible line, the blue ray of wave-length 469, distinguishing stars of the Wolf-Rayet type.

The photographic study of these two nebulæ, lately set on foot by Dr. Scheiner at Potsdam, may be expected to add much and rapidly to our knowledge of their nature and conformation. The images obtained of them, although only half a millimetre in diameter, show a considerable amount of detail. They confirm the annular shape attributed to them on the warrant of telescopic observations, and bring out, with singular strength, the central nuclei which the best telescopes have not always availed to display. In the photographs these are, nevertheless, the brightest parts of each formation. Yet they are mere irregular condensations, with no pretentions to a stellar nature. The superiority of their actinic power repeats the phenomenon first brought into notice by photographs of the Lyra nebula, and seems to point to a general law. Dr. Scheiner thinks it can only be accounted for by supposing a predominant quantity of some peculiar gas emitting, in the main, highly refrangible light, to be collected in the central regions of planetary nebulæ;‡ yet the resulting nuclei, when they can be seen at all, shine with a white light, bear a star-like aspect, and probably give continuous spectra. The problem of their real constitution is thus far from easy to solve. But, whatever the secret of their photographic effectiveness, it is already tolerably evident that they play a part of fundamental importance in determining the structure of planetary nebulæ. They are perhaps the primary seats of the forces by which these interesting objects are moulded into characteristic shapes; and the circumstance may be regarded as a particularly fortunate one that the camera is so well adapted to display and emphasize their complex relationships with the nebulous masses organized, as it were, under their immediate control.

* *Monthly Notices*, vol. xlviii., p. 391.
† *Astr. Nach.*, No. 1018.

LIGHTNING PHOTOGRAPHS.

By A. C. Ranyard.

MR. GLEW, whose lightning photograph appears at the top left-hand corner of our plate, has succeeded in roughly measuring the duration of a flash of lightning. The ingenious method he adopted will be found described in his letter published in our correspondence column. There is some doubt as to the direction in which the lens with which the photograph was taken was moving during the interval between the flashes. If, as seems most probable, the lens was moving at the time of the flash from the left-hand side of the plate towards the right, the first flash must have been the faintest, and it must have died away comparatively slowly to be succeeded after an interval, which probably was not greater than about the fortieth of a second, by a brighter flash, the duration of which must have been less than the two-hundredth of a second. Again, after a slightly longer interval (perhaps the thirtieth of a second), there came the brightest of the three flashes, which died away in an interval less than the two-hundredth of a second.

If instead of moving from left to right the lens with which the photograph was taken was moving from right to left during the interval between the flashes, the first flash must have been the brightest, and it must have begun with a faint glow which brightened gradually during an interval less than the two-hundredth of a second until it became intensely brilliant, and then suddenly ceased. The scale of our plate is not sufficient to show this, but the shading off of each of the photographic images of the flashes towards the right hand is distinctly recognizable in the silver prints from Mr. Glew's negative. Probably the duration of the discharge, and its mode of arriving at any particular point in its course, varies with the conducting power of the air or cloud or the terrestrial bodies from which it is derived. This is well illustrated by the old experiment of placing a little loose gunpowder over the interval between two wires, and dispersing it without explosion by the discharge from a Leyden jar sent through the wires, after which a few inches of wet string are inter-

‡ *Astr. Nach.*, No. 3086.

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posed in the circuit, and the discharge is found to be sufficiently prolonged to fire the gunpowder before it is blown away.

From what we know of the travelling of waves along a narrow channel, it seems probable that the maximum electric disturbance would lead the way, and that it would be followed by a decreasing wave, rather than that a small disturbance should arrive first and be followed by an increasing disturbance, but it is desirable that this question should be set at rest; possibly Mr. Glew, or somebody in the future, may succeed in taking lightning photographs with a lens moving uniformly in a circle of sufficient size, with respect to the photographic plate, to enable us to determine the part of the circular path which was being described at the time that the photograph was taken.

The photograph at the top right-hand corner of our plate is believed by Mr. Dunn, who took it, and by his father, who was standing beside him at the time, to be a photograph of ball lightning. At about a quarter past ten on the evening of the 17th of July, 1891, Mr. W. F. Dunn and his father were standing at the open window of an upper room of their house in Westmoreland Road, Newcastle-on-Tyne. A severe thunderstorm was passing over the town, and the son had his camera pointed out of the window ready to take a photograph. The window overlooks the valley of the Tyne from a point above the Elswick Works. Suddenly the father saw a ball of fire, which appeared to him to be over the river, and to be moving in an easterly direction down towards the sea—not very rapidly, but faster than a man could run. The ball appeared to Mr. Dunn to be about two feet in diameter, and when nearly opposite to the house it stopped and then disappeared. Mr. Dunn thinks that about the time it stopped he called to his son to make an exposure. The son says that he took off the cap of the camera for an instant, and replaced it. The plate was developed in the ordinary way. It was by no means the first plate which Mr. Dunn, jun., had developed. He had been practising photography for some months, and had obtained several successful photographs, and never before or since has developed a plate which showed a patch or streaks similar to those found upon this plate. Both father and son have made statutory declarations before a magistrate as to what they saw and believe with respect to the photograph, and they have kindly submitted the statutory declarations, as well as the original negative, to me for examination. I have also had an opportunity of asking Mr. Dunn, sen., some questions as to what he remembers. He says that the ball of fire appeared to be about twice the diameter of the moon. If it was two feet in diameter, this would correspond to a distance of about 115 feet; but the place over the Tyne where the ball of fire appeared to be is certainly at a much greater distance than this from his house. The camera with which the photograph was taken has a focal length of about $5\frac{1}{2}$ inches; consequently, a photograph of the full moon taken with it would only have a diameter of about $\frac{1}{20}$th of an inch, but the bright patch which he believes to correspond with the ball lightning has a diameter of $1\frac{1}{4}$ inches on the original negative. Therefore, if it represents the ball of fire, either the ball must have had a diameter of about 15°, or it must have been much nearer to the window than Mr. Dunn supposed, or its diameter must have been much greater than two feet. I am far from feeling convinced that Mr. Dunn has succeeded in photographing ball lightning, but it seemed desirable to reproduce his photograph, with such particulars as I could gather; for a photograph showing somewhat similar streaks and patches was shown to me in 1889. It had been taken during the thunderstorm which broke over the metropolis with great violence on the 6th of June, 1889, and was believed by the young man who took it—and who kindly called upon me and allowed me to question him—to be a photograph of lightning, though I was inclined to attribute the marks upon his plate to want of care in developing.

The two lower photographs shown on the plate published with this number of KNOWLEDGE are copied from photographs sent me by Mr. S. W. Burnham, who, our readers will regret to hear, is about to leave the Lick Observatory and return to his old profession in Chicago.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

To the Editor of KNOWLEDGE.

DEAR SIR,—I beg to enclose a photograph of a discharge of lightning. The photograph was taken about 9.50 p.m. on Tuesday, June 28th, 1892. The camera was pointed S.E. from the door, at 156, Clapham Road. The lens was secured to the hammer of an electric bell, giving nine complete vibrations per second, the amplitude being about $\frac{1}{4}$ of an inch. It is evident that the main flash and its side forks all took place in less than the half of one vibration, and the motion of the lens separated the three component flashes, which to the eye would have appeared to be superposed. I compute from measurements that the whole discharge occupied about the $\frac{1}{20}$th part of a second, and the interval between the components about $\frac{1}{40}$th of a second. It will be seen that the right-hand side of each spark is fainter than the left, showing that the duration of each component was considerable, and not of the same intensity throughout its existence. The original negative shows this a little clearer than the print. Thomas's "Sandell" plates were used, which being thickly coated, in separate layers, has prevented halation defects. Some of the shadows of chimney-pots are due to sheet lightning previous to the grand flash. The vibrations of the lens were in the same plane as the plate, and in the direction of its length.

Yours faithfully,
156, Clapham Road, London, S.W., F. H. GLEW.
July 11th, 1892.

P.S.—It will be seen that one portion of the flash is converted into chain lightning, this being due to the motion of the lens being almost in the direction of the length of this part of the flash, and in consequence of this the different curves have been more or less superposed in direction of length, in the form of a chain. I think this throws some light on the so-called chain lightning as seen by the eye, for if the duration of a compound spark is so much as $\frac{1}{20}$th of a second, it is possible for the eye (corresponding to the lens of the camera) to move through a certain distance, and if this movement of the eye happens to be in the direction of the length of the compound spark, then its components will be drawn out into a chain-like structure or complex ripple. Perhaps the duration may be even greater than $\frac{1}{20}$th of a second in some cases, and the eye may be set in motion by the first component of the flash. As the tendency of the eye would be to move in order to bring the object into the best position for distinct vision, so I think the effect of chain lightning might be formed in this way, or by accidental motion of the eye of the observer during the display.—F. H. G.

DOUBLE STAR ORBITS.

To the Editor of Knowledge.

Sir,—I am glad to hear that Mr. See is about to publish a fuller exposition of his views as to the orbits of double stars. I ask leave to add a few words, however, in order that my objection may be more completely dealt with in his forthcoming work. I think I am correct in saying that equality (or a near approach to equality) of mass is *one* of the circumstances which, in his opinion, tends to produce the high eccentricity of binary star orbits; and if this be so, we ought to obtain *on the average* a higher eccentricity for binaries with equal than with unequal masses. I did not, of course, intend to apply this reasoning to each individual case, but I think the average in the two cases is about the same.

A point of considerable interest raised by Mr. See is that of the age of a binary system. It would follow, I think, from his principles that the orbits of the close binaries recently discovered by the spectroscope should be pretty nearly circular. Further spectroscopic observation may throw light on this subject. All the spectroscopic binaries or variables of the Algol type have, so far as I know, spectra of the first type. From this we might, perhaps, infer that binaries with this spectrum, like Sirius and Castor, were of more recent date than binaries with spectra of the second (or solar) type, and that consequently their orbits should be on the average less eccentric. I doubt whether this is so.

We are, unfortunately, unable to observe the effects of nearly equal masses in the binaries within the solar system. The earth and moon are not far from the closest approach in the case, but the ratio of the masses is eighty to one. Is the mass of Neptune's satellite known?

Truly yours,

W. H. S. Monck.

Notice of Book.

Island Life. By Alfred Russel Wallace. Second Edition. (Macmillan & Co.)—It is about sixteen years since Mr. Wallace laid the foundations of that branch of combined biological and geographical science with which his name will always be associated, by the publication of his great and comprehensive work on the "Geographical Distribution of Animals," a work followed in the course of four years by a smaller volume containing a further exposition of his views with regard to insular faunas and floras, and entitled "Island Life." Now, after a further interval of twelve years, we have a second edition of the latter work, and it is pretty good evidence of the general soundness of the principles originally enunciated that the author has practically nothing to retract, and scarcely anything of his original arguments even to modify. The changes consist chiefly of additions to the stores of facts already recorded about the plants and animals of Great Britain, Japan, the Galapagos, the Sandwich Islands, Borneo, Madagascar, and New Zealand, and these are the results of observations made since the issue of the first edition. No better illustration could be given than this book affords of the marvellous change that has been introduced into biological studies, and the immense amount of additional interest that has been imparted to them by the abandonment of the idea of the fixity of species, and the acceptance of the principles of natural selection and evolution. To one who imagined that each species had been specially formed in the region it now inhabits, and had always existed there since its first formation, what could have seemed more dry and uninteresting than a catalogue of the fauna and flora of a district? On the other hand, to the thoughtful evolutionist who recognizes that the whole of the present condition of things is a product brought about by the inter-action through long ages of various more or less opposing influences, the very reverse is the case, and every name in such a list becomes encircled with a halo of romance as the questions arise, How came this organism to be what it is, and where it is? What past changes in its surroundings does it bear witness to? How can it be used to help to unravel the tangled skein of the primeval history, both of its race and of its present dwelling-place? And these are the questions which are ever kept in view by the author of "Island Life," whence arises in the experience of the reader a mental invigoration and stimulus as he follows the clear exposition of the argument.

Islands, in consequence of their restricted area and definite boundaries, and the barrier the surrounding seas offer to the migration of many organisms, are specially well adapted for the study of questions connected with the distribution of animal and vegetable life. But from the point of view of the naturalist, there are remarkable differences between islands, depending upon the time and method of their origin. The British Isles well illustrate one of these types, that of the recent continental, the comparative shallowness of the water that separates them from the Continent indicating that their severance took place at no very remote period. The plants and animals accordingly show a close resemblance to those of the Continent, and there does not appear to have been time enough for the production of more than a few distinct forms. From our poverty in indigenous species of the larger animals, Mr. Wallace argues that the connection of Great Britain with the Continent, after the last glacial period had exterminated the previous and richer fauna, was of short duration; thus, while Germany has nearly ninety species of land mammalia, Britain, having been early cut off, has only forty; it has also a still smaller proportion of reptiles and amphibia. In none of these cases has the effect of their isolation been such as to produce a distinct species or even variety. Amongst birds, however, we have the red grouse of the northern moors as a peculiar species, as well as two peculiar varieties of tits; while our lakes yield a goodly number of fishes which are found nowhere else. The insect fauna exhibits more striking peculiarities. A list of eighty-nine species and varieties of butterflies and moths is given, which, so far as present knowledge goes, are confined to Britain. These include the splendid "large copper" butterfly, the glory of the old collectors, but now, alas, extinct. Of beetles, again, sixty-seven are enumerated which have not been discovered elsewhere. Too much reliance, however, must not be placed on these numbers, for it may well be that many of these insects, especially the smaller species, have hitherto been overlooked on the larger area of the Continent, and may be expected yet to turn up there. This seems the more likely to be the case, inasmuch as, although fifteen additional species have been included since the first edition of "Island Life" was published, there have been a still larger number removed from the old list in consequence of their having been since found on the Continent, so that the total number of apparently peculiar beetles is actually reduced from seventy-two to sixty-seven. Whatever allowances be thus made, however, there still remains, as Mr. Wallace points out, enough to distinguish our insular fauna from that of the Continent.

The case of Madagascar is a great contrast to this; here we have an island separated by deep water from the adjacent continent, indicating a much more ancient separation, and consequently there is much greater dissimilarity in the types of both animal and vegetable life; in fact, the

fauna and flora of Madagascar, though showing African affinities, is remarkable for the extraordinary differences which exist between it and that of the continent opposite. Hence, Mr. Wallace concludes that it was severed from Africa before that continent received its present characteristic assemblage of plants and animals, which apparently migrated into it from more northerly parts. Madagascar is thus regarded as having preserved its lemurs, tanrecs, and other peculiar animals, as relics from a time dating back at least to the Miocene period, before Africa itself had received the baboons, antelopes, hippopotamus, &c., which now distinguish it, but which are absent from Madagascar.

The Sandwich Islands form a good type of the third division, that of oceanic islands, which have never been connected with any continent at all, but have been formed, usually either as volcanoes or coral islands in mid-ocean. In such cases we of course find no indigenous land mammalia, since there would be no means for their conveyance thither, and whatever forms of life the islands have received may be expected to have come from various quarters, the winds and ocean currents being the chief means of their introduction. Hence we find a somewhat mixed assemblage, showing no close conformity to those of any one particular continent. The flora of the Sandwich Islands is very rich and extremely peculiar, there being, out of 705 flowering plants, no less than 574 which are quite peculiar to the islands. Some of these, belonging to genera which in other parts of the world are low herbaceous plants, attain the dimensions and habit of shrubs, and even sometimes of trees; such is the case with certain lobelias, violets, and compositæ.

In connection with New Zealand a most interesting sketch is given of probable geological and geographical changes in the remote past, by which Mr. Wallace proposes to explain the peculiar and puzzling character of the present flora and fauna of the islands. According to this theory New Zealand received the ancestors of its recently extinct gigantic wingless birds, the moas, and of the present rapidly disappearing apteryx or kiwi, by a connection with north-eastern Australia, while that part of the island was still unconnected with its western half, and had not yet received its characteristic marsupial fauna, a route by which also it received that part of its flora which is tropical in character. Recent information as to soundings round New Zealand, and the discovery of fossil tertiary and cretaceous plants in both New Zealand and Australia, enable the argument here to be more fully elaborated than was possible in the former edition.

RUMINANTS AND THEIR DISTRIBUTION.

By R. Lydekker, B.A.Cantab.

FROM early times we find the function of ruminating, or "chewing the cud," recognized as a peculiarity of the group of mammals known in semi-popular language as ruminants. Thus in Deuteronomy the animals permitted for food are those that "chew the cud and part the hoof"; while the swine "which part the hoof but do not chew the cud" are forbidden. On the other hand, the camel, which chews the cud but has not paired hoofs, is in the forbidden list. In the permitted animals we thus have a recognition of the group of ruminants as represented by oxen, sheep, and deer; of which no better short definition can be given than that they chew the cud and have each foot furnished with a pair of hoofs symmetrical to a vertical line between them. The want of the paired hoofs in the camels, which are also cud-chewers, shows, however, that these two characteristics will not hold good for the entire group. As we proceed, we shall find that there are structural features, common to the group, in addition to the peculiarity of rumination; but, before going further, we may observe that the recognition of their paired hoofs, coupled with the absence of rumination, is an exact statement of the relationship of the swine to the true ruminants.

The word "ruminant" comes from the Latin *rumen*, which was applied both to the "cud" and to that part of the stomach in which the latter is contained previous to chewing. The Greeks had a word *meruko*, or *merukizo* (from *meruo*, to revolve), to express this action of cud-chewing, and a derivative from the former was used by Aristotle to designate ruminants, who thus first distinguished the group by a definite name. This early recognition of the ruminants as a group is probably due to their importance to man, the Biblical record showing that they yielded the only mammalian food permitted to the Hebrew, and this pre-eminence as a source of food has scarcely decreased to the present day. They are, moreover, now the dominant type of larger mammals, as witness the herds of bison which lately roamed over the American prairies, and the droves of antelopes on the African "veldt."

Commencing with the function of rumination, we may observe that it is a re-mastication of grass or other vegetable food, swallowed almost as soon as plucked, and transferred to a special receptacle in the stomach. From this, it is regurgitated into the mouth by a reversed action of the muscles of the throat, and, after having undergone mastication—or rumination—is transferred to the digesting part of the stomach. Now, it is evident that this complicated arrangement, so different from that of other animals, must be of some special advantage to the ruminants. As a matter of fact, these animals, like other large herbivora, are obliged to consume a large quantity of food to obtain sufficient nutriment; and it is obvious that if this food had to be masticated as soon as plucked, the operation of feeding would be very protracted; but by the arrangement mentioned the requisite amount of food can be gathered within a comparatively short time, and the animals can then retire to ruminate in concealment. It is superfluous to comment on the advantage this is to creatures which, like many ruminants, have but little means of defending themselves against carnivorous foes; but we may mention that many still further increase this advantage by feeding only at dawn or evening, when they are far less conspicuous than in the mid-day glare. There is, moreover, evidence that when ruminants first appeared, this rapid feeding was of more importance than at the present day, since while many of the modern larger forms, like oxen, antelopes, and deer, are provided with formidable weapons in the shape of horns or antlers with which they can keep foes at bay, in earlier times such weapons were either absent or but feebly developed.

Fig. 1.—The first upper molar and last two premolars of a Ruminant.

Seeing, then, that the function of rumination is correlated with a special compartment of the stomach for the temporary reception of the freshly-gathered food, it would be expected that animals thus provided would also possess an efficient masticating arrangement for reducing their food to the condition in which it yields the fullest nutriment. Such, indeed, is the case, the grinding-teeth of ruminants being of a complex structure, unknown elsewhere. In our previous article on "Teeth and their Variations," we have indicated the characteristic structure

of the grinding or cheek-teeth of the ruminants, and have shown how the last three in the upper jaw (Fig. 1) are composed of four columns, of varying height, of which the two inner ones are crescent-shaped. It was, moreover, shown at the same time how these *selenodont* (crescent-like) teeth could be traced back by gradations to the simpler *bunodont* (hillock-like) teeth of the swine. The lower grinding-teeth having their crescents directed the opposite way to those of the upper jaw, and both upper and lower teeth consisting of layers of different hardness, we can scarcely imagine a better masticating machine than is presented by the opposition of the two series of grinding-teeth of these animals. Bearing in mind this structure, the definition of cud-chewing, selenodont mammals will suffice to distinguish the ruminants from all other animals. When, however, we say that these characteristics distinguish them from all other animals, it must be added that this refers only to those of the present day. We have already seen how the Mosaic law recognized the similarity in the structure of the hoofs of the ruminants and the swine, and it is curious that while under the Cuvierian system of zoology these two groups were widely sundered, modern palæontological researches have shown that they are really closely related, the want of the power of chewing the cud, with the correlated absence of the selenodont structure of the teeth, being the chief essential features in which the latter differ from the former.

Here a curious problem is presented to those who put their faith in a mode of evolution dependent only upon so-called natural causes, in that it is impossible to give any adequate explanation of what possible advantage would be the development of an incipient selenodont structure in the teeth of the early swine-like ungulata, or at what precise stage the function of chewing the cud, with the concomitant development of a separate compartment in the stomach, was superadded to the normal mode of feeding characteristic of the swine.

Fig. 2. — Bones of the hind foot of a Ruminant. The letters indicate the lower bones of the ankle. (After Osborn.)

Here we must say a few words as to the structure of the ruminant foot. The "cloven hoof" of ruminants and swine has become such a proverbial expression that the idea may still linger that this is due to the fission of a single hoof, like that of a horse. As we have endeavoured to show in our article on "Rudimentary Structures," nothing could, however, be further from the truth; the two hoofs of a ruminant (Fig. 2) corresponding to the terminal joints of our own middle and ring fingers (or the corresponding toes), which are the third and fourth of the typical series of five. The lateral or spurious hoofs (not shown in Fig. 2) of the ruminants represent our own index (2nd) and little (5th) fingers, or toes. It is a further peculiarity of the true ruminants and camels that the two separate bones which in the swine connect the two large digits with the wrist or ankle are fused into a single cannon-bone (Fig. 2); the primary dual origin of which is indicated by the two distinct pulley-like surfaces at the lower end, which carry the bones of the digits. The peculiar little ruminants known as the chevrotains—of which more anon—retain, however, evidences of their kinship with the swine, in that some of them have the two elements of the front cannon-bone—or metacarpals as they are then called—quite separate from one another. Indeed, as indicated in the article last cited, in the same manner as we may trace a transition from the selenodont teeth of the ruminants to the bunodont ones of the swine, we may mark how the two-toed and cannon-boned ruminants passed into swine-like animals, with four toes supported by as many separate metacarpal bones.

Having now mentioned the leading characters of a modern ruminant, as distinct from other mammals, we may refer to a peculiarity, which, although by no means characteristic of all, is a striking one, and one sharply differentiating the group from all others. This is the tendency to the development of appendages on the skull, arranged in a pair at right angles to its longer axis, and taking the form either of solid branching antlers, as in the deer, or of hollow sheaths of horn covering bony cores on the skull, as in the oxen and antelopes. The distinction between antlers and horns, having been described in an earlier article, need not further engage our attention.

Passing to the consideration of the various kinds of cud-chewing mammals, we find that the true ruminants, or those with hoofs, no upper front teeth, and a cannon-bone in both limbs, arrange themselves in several minor groups. The most important to man are the "hollow-horned ruminants," such as oxen, sheep, goats, and antelopes, all of which are characterized by the presence of horns, at least in the males. The variety of form assumed by the horns render this group one of the most attractive of all animals; and we have but to recall the curved and smooth horns of the oxen, the equally massive but wrinkled ones of the wild sheep, those of the ibex with their knotted points and scimitar-like backward sweep, the spear-like form of those of the gemsbok, and the spiral twist of those of the kudu and eland, to realize the variety of contour assumed by these appendages.

The oxen (including bison and buffaloes) are, with the exception of the American bison, Old World types, and were formerly abundant in Europe, where, however, they are now only represented by the bison preserved in the forests of Lithuania and the Caucasus, and by the half wild cattle (Fig. 3) of Chillingham and some other British parks, which have been thought to be the direct descendants of the British wild ox, or aurochs, of Cæsar's time, but are more probably derived from ancient domesticated breeds which have reverted to a nearly wild state. True wild oxen now exist only in India and the adjacent regions, while wild buffalo occur both in India and Africa.

Equally characteristic of the Old World are wild sheep and goats, the "big-horn" being an outlying North American type. Both groups are essentially mountain animals, the head-quarters of the former being the highlands of Central Asia, while on the southern flanks of the same mountain-barrier the latter are more abundant. Both are also represented in the mountains of Europe; but in peninsular India there is but the wild goat of the Nilgerries, while in the whole of Africa we have only the wild sheep of Barbary and the ibex of Abyssinia. This absence of sheep and goats from Africa may, perhaps, be due to the fact that these animals are of comparatively late origin, and were probably poorly represented at the time when the other ruminants entered that continent from the

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north. The musk ox of Arctic America is an aberrant form allied to the sheep.

The antelopes have a distribution nearly the reverse of that of the sheep and goats, the great majority being restricted to Africa, where there are probably fully ninety species, against about a score in all the rest of the world, except Arabia and Syria, of which the fauna is allied to

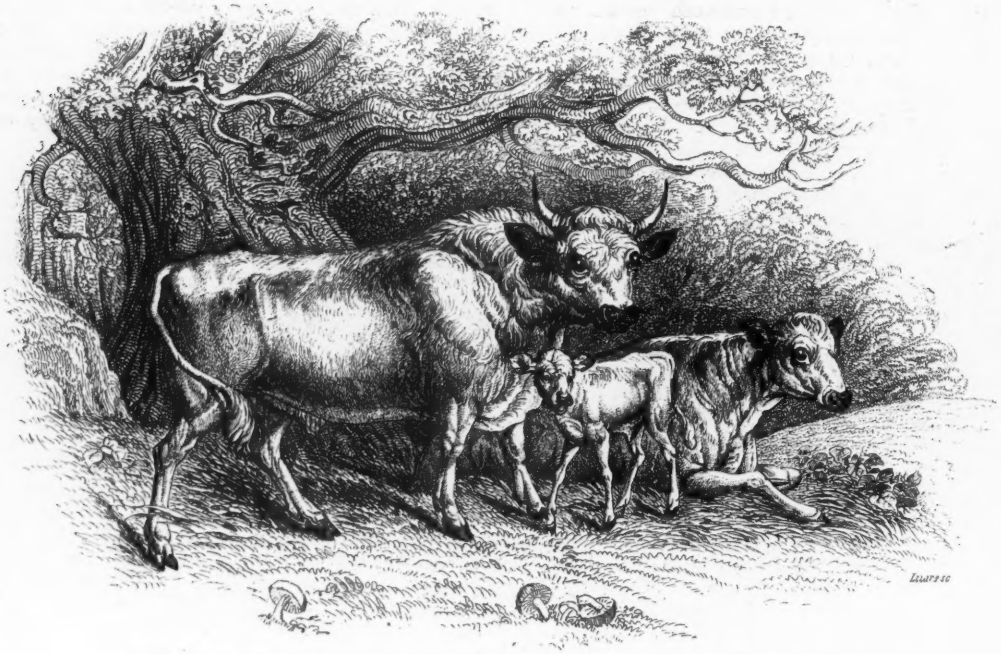


Fig. 3.—The White Cattle of Chillingham Park, Northumberland. (From Jardine.)

that of Africa. Indeed, the only typical antelopes found beyond these regions are the black-buck, the nilgai, the four-horned antelope of India, the saiga of Tartary, the chiru of Tibet, and several members of the widely distributed gazelles. The rings marking the horns of the latter (Fig. 4) and many other antelopes are very distinctive of the group, although by no means universal. The European chamois, the goat-antelopes of India and China, and the Rocky Mountain goat of America, serve to connect the typical antelopes with the goats, and it is these alone which represent the group in Europe, to the eastward of India, and in North America. Seeing that in Tertiary times, antelopes of African types occurred in Southern Europe and India, it is difficult to determine why the group should have so dwindled or disappeared there; although we can readily account for their extraordinary development when they once obtained an entry into Africa, on account of the immense area open to them, in which there was no competition by any other ruminants except buffaloes and giraffes.

Fig. 4.—Horns of Gazelle. (From Günther.)

To the zoologist, Africa is indeed a country characterized by the number of animals living there which have disappeared from other regions; and there is no better instance of this survival than the giraffe, a ruminant that, as regards its cranial appendages, stands midway between the hollow-horned group and the deer. We are all familiar with the ungainly and yet beautiful form of the giraffe; but it is probably less well known that giraffes once roamed over Greece, Persia, India, and China, where, as in Africa at the present day, they were accompanied by ostriches and hippopotami. And here again we are confronted by the problem how to account for the disappearance from regions apparently exactly suited to their habits, of all these animals. The giraffe is, however, not only the sole survivor of several extinct species of its own kind,

Fig. 5.—Skull of Sivathere, from the Pliocene of India.

but it likewise represents a lost group of Old World ruminants, intermediate between the horned and antlered types. The head-quarters of this group was India, where,

among other forms, occurs the gigantic sivathere, rivalling the elephant in bulk, and characterized by its two pairs of horns (Fig. 5), of which the hindmost were branching and antler-like, although apparently never shed, and were probably covered during life with skin and hair.

If our attention has been turned to Africa as the head-quarters of antelopes and giraffes, it must be directed to other regions when we come to the deer, since, with the exception of the Barbary stag, there is no representative of the group in all that continent. With few exceptions, deer are characterized by the antlers of the males, the reindeer alone having these appendages in both sexes. They are the only true ruminants found in South America, where most of the species have comparatively simple antlers, and thus show affinity with the early fossil types, some of which were antlerless. Allied species range through North America, but it is not till the north of that continent that we find in the wapiti a representative of our own red deer. The red deer group extends through Europe and a large part of Central Asia, but in India and the Malayan region it is replaced by the rusine deer, like the sambar, in which the antlers (Fig. 6, *a*) lack the bez-tine of the red deer

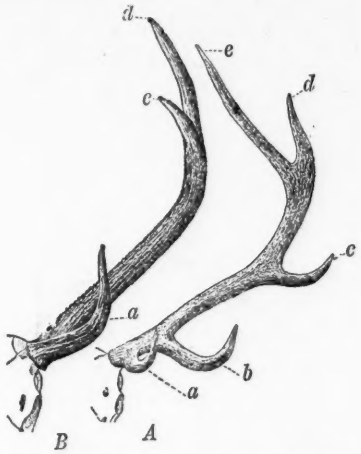


Fig. 6.—Antlers of red (A) and sambar (B) deer. *a* brow, *b* bez, *c* trez-tine, *d e* surroyals. (After Blanford).

(*ibid.*, *b*). Other marked varieties of antler are exhibited by the elk, the fallow deer, and the reindeer; but none of these approach those of the extinct Irish deer, which may have an eleven feet span from tip to tip. It is noteworthy that in a few small deer in which the males have no antlers, they are compensated by having long tusks in the upper jaw.

The tiny oriental chevrotains, and the larger African water-chevrotain, form a group quite distinct from all the above, and are in some respects related to the swine. None of them have antlers, and the African species is the only living ruminant in which the two elements of the front cannon-bone remain separate, thus affording another instance of the survival of primitive forms in Africa.

Lastly, we have the group of camels and llamas, which differ from other ruminants in that their feet form cushion-like pads, while their upper jaws possess front teeth. According to the latest researches it is considered probable that this group has diverged from primitive swine-like animals quite independently of the true ruminants, an inference which, if confirmed, is very remarkable, showing that selenodont teeth, a complex stomach, the function of rumination, and the single cannon bone, have been acquired quite independently in the two groups. The present distribution of camels and llamas is remarkable, the former being confined to Africa and Asia, and the latter to South America. Here, however, geology comes to our aid, for in former times camel-like ruminants were abundant in North America, while the fossil camels of India show certain resemblances to the llamas, and we can thus understand how the present distribution of the two sections of the group has come about. With the possible exception of some herds of the Bactrian species in Central Asia, wild camels are now unknown, and we cannot even determine the original habitat of the single-humped species.

Thus ends our brief survey of the chief groups of living ruminants and their distribution. Did space permit, we might go on to refer to their extreme importance to man, both as sources of food and of clothing, and as beasts of draught and burden, but having reached our limits, we trust that we may have aroused in our readers an interest in these highly specialized animals which may induce some of them to devote further consideration to the subject.

THE CURRENTS OF THE NORTH ATLANTIC.

By Richard Beynon, F.R.G.S.

THE development of our over-sea trade, especially the Transatlantic section of it, has, during the present century, been phenomenal. Oceanic knowledge has, however, quite failed to keep pace with it. It is matter for regret that our information respecting the Atlantic, its currents, ice limits, and the meteorological conditions obtaining in the atmosphere superincumbent to its surface is far from satisfactory, and greatly behind what the importance of Transatlantic commerce leads one to expect.

We do not intend, in the present paper, to discuss the theories which best account for the formation of the great equatorial current of the Atlantic, but to deal with the oceanic circulation which lies north of its point of bifurcation off Cape San Roque. In passing, it may be stated that the western drift of the ocean in tropical regions has been known ever since Columbus made his memorable voyages across the Atlantic. That adventurous navigator states, "I regard it as proved that the waters of the sea move from east to west as do the heavens (apparently), *con los ceilos*."

The progress of the north-westerly moving section of the equatorial current of the Atlantic is so well known that it needs but the briefest allusion. It skirts the shores of Brazil, and then follows the trend of the shores of the Caribbean Sea, and so reaches the most easterly point of Yucatan. Here a division takes place, one part of its waters making the tour of the Gulf of Mexico, while the other section flows along a more direct route by the western extremity of Cuba to Florida, where a reunion takes place, and the united current, its impetus increased by north-westerly drifts, the portion of the current which has been entangled among the West Indian Archipelago, flows forth to carry vast stores of heat to the north-west of Europe.

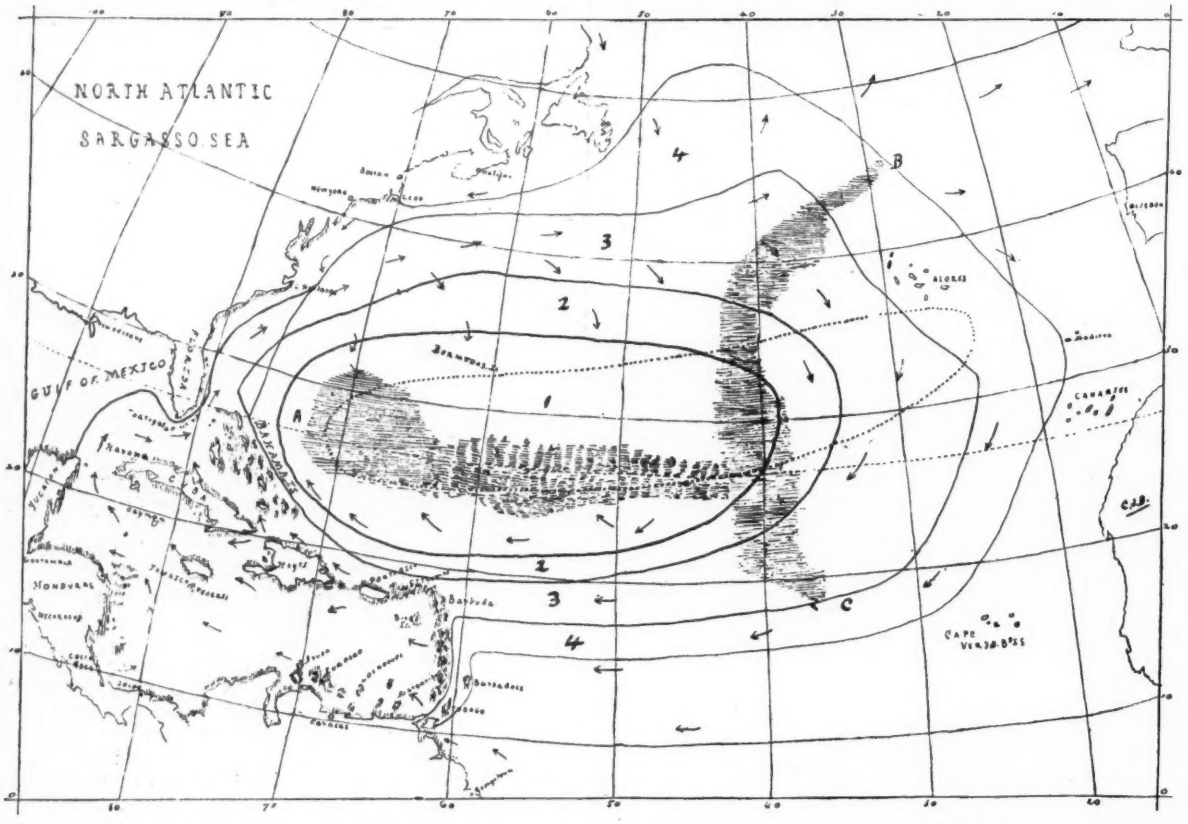
From Florida to Cape Hatteras the shores experience the full benefits of a stream of warm water, whose temperature approximates to 80° F., and whose rate of flow is some 70 or 80 miles per day. At this point, however, the eastering influence of the cold water flowing equatorwards

from the north Polar regions begins to be felt, and it is a matter of considerable difficulty to assess the value of this force, or to locate with any degree of accuracy the line along which it is applied. The general direction of the Labrador current and its ramifications was first discovered by Cabot in 1497, but although many attempts have been made to give an exact position to the line of demarcation between the waters of the Gulf Stream and those of the icy current contiguous to it, our present knowledge of the subject is yet far from being marked by scientific precision.

Navigators report that the Gulf Stream swirls by its antagonistic neighbour with a clearly defined ripple, that on leaving the former current for the latter the transition is rendered perceptible to the sight by the water changing from deep blue to light green, and to the sense of touch by a very marked reduction in the temperature. Scientific research, however, fails to establish the existence of such well-marked boundaries, although the fact of Admiral Milne, in the line of battle ship *Nile*, finding a variation of temperature of some 25° between the sea at his stern and at his bow is indisputable. The most reliable index that a vessel is in the vicinity of the meeting of the waters is the partial condensation of the aqueous vapour, for the convergence of two air columns of differing temperatures and humidities often results in dense fogs. But even this hygrometric evidence is not absolutely reliable as revealing the exact *locale* of the dividing line. The variations of the anti-trades are frequently the cause of the interposition of air columns from the Gulf Stream between the atmospheric masses superincumbent to the Labrador current. The eastern side of Newfoundland has its mean annual temperature raised considerably by its proximity to the warm current, while Nova Scotia benefits in a lesser but still marked degree. Halifax harbour is never blocked by field ice, and the formation of sheet ice in the harbour itself never obstructs the navigation of steamships. The mean temperature for the month of May averages 44° or 45° F.

Somewhere between the latitude of Cape Cod and that of Newfoundland, the Gulf current undergoes the process of division. One section flows to the north-east towards Northern Europe, while the other pursues an easterly direction, which gradually becomes south-east and then almost due south.

It will be readily seen that the difficulty of obtaining accurate information relative to the direction and speed of ocean currents is very great, and that it is only by many observations extended over a number of years that sufficient data can be procured to generalize from. The Hydrographical Department of the United States has conferred lasting benefits upon Atlantic navigators by



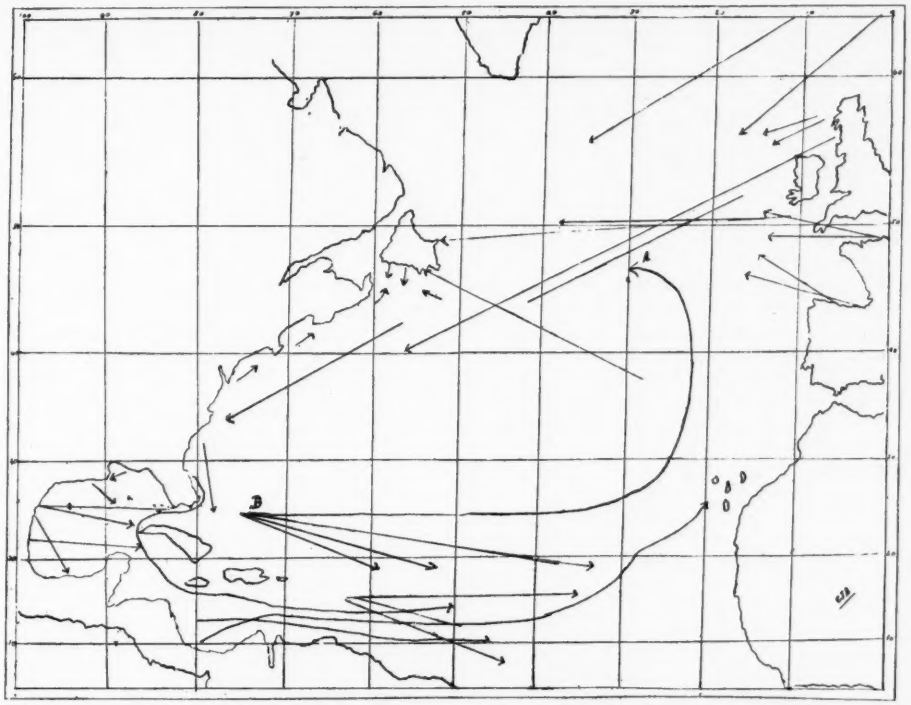
Explanation of sketch showing the North Atlantic Sargasso.—The arrows indicate the direction of the currents. The areas marked 1, 2, 3, 4 show the accumulation of different quantities of Sargasso. Fig. 1 marks the area of greatest density. The minimum of frequency is encountered in the zone numbered 4, while beyond that area weed accumulation is hardly ever noticeable. The shaded coast-line signifies the presence of a weed there identical with the weeds occurrent in the Sargasso Sea. In fact, the shaded coasts are the strips of littoral from which the Sargasso weed is detached. The dotted ellipse signifies the areas of frequent calms. The shaded portion of the North Atlantic, marked A, B, C, marks the limits of the Sargasso Sea as laid down by Humboldt.

their efforts in this direction, and not the least valuable of their contributions to North Atlantic lore is the determination, with approximate exactitude, of its currents and drifts.

The general character of the drifts has been long known. Drifted matter from the New World has been found cast upon the shores of the Old since the days of Columbus. The most remarkable drift on record is that effected by the ship "W. L. White." This vessel, an American schooner, was abandoned off Delaware Bay during the terrible snowstorm of 13th March, 1888. She drifted across the Atlantic, assisted doubtless by wind as well as set of current, and finally stranded, after a voyage of 5000 miles, upon one of the outer Hebrides. From March 13th, 1888, to January 23rd, 1889, was the time occupied on this drift. About 1760 A.D., an English man-of-war was wrecked near St. Domingo, and her mainmast was afterwards found stranded on the shores of the Pentland Firth.

Such instances as these, however interesting they may be, afford but little *detail* of the set of the ocean currents. These details a bottle-chart issued by the United States Marine Authorities supplies to a very material extent. The plan adopted is the throwing overboard of bottles in which is a record of the ship's name, latitude and longitude, and date. Of course the co-operation of the masters of the merchant vessels trading to the United States is necessary. The number of bottles which are traced bears but a small proportion to the numbers thrown overboard, but still they are sufficient to enable pretty accurate courses to be assigned for the ocean currents. Seventy-five bottle-tracks are laid down on the chart published by the Hydrographic office at Washington, and an examination of those which are laid down on the accompanying sketch-map will reveal at a glance the system of oceanic circulation in the North Atlantic.

The indraft into the Gulf of Mexico is clearly indicated, as also is the drift of the icy Arctic current, which flows equatorwards along a course lying to the westward of that followed by the Gulf Stream. The track of the Gulf Stream from Newfoundland is almost coincident with the fiftieth parallel of latitude. Looking at the eastern portion of the chart, it will be seen that the existence of a powerful indraft from the north-west into the Bay of Biscay and its enclosing shores is clearly demonstrated. It is the failure to recognize aright the influence of this current during the prevalence of south-westerly winds that has led to so many ships being cast ashore in the vicinity of Cape Finisterre. Of these disasters that of H.M.S. *Serpent* was the most terrible, but the current is a veritable danger-trap to ship-masters given to corner shaving, as the records of wreck enquiry courts show but too plainly.



Explanation of sketch showing bottle-drifts.—The arrow-heads show the spot where the bottle was thrown overboard. Consequently, the line of drift followed will be from the arrow-head to the other unmarked end of the line. In drawing the drift-lines some attention has been paid to already-obtained knowledge relative to their direction, for it is not always correct to assume that the drifting object moves in a straight line from the commencement of its voyage to where it is picked up. This is most noticeable in the drift marked A, B, the bottle following a course almost identical with the eastern and southern boundaries of the Sargasso Sea.

The bottle-chart shows an elliptical area of ocean water whose principal axis lies along the thirtieth parallel of latitude, and this area is identical with the Sargasso Sea. From the incipience of Transatlantic voyaging down to the past few years, our knowledge of this sea has remained almost stationary. Columbus discovered it, and commented upon it, and the nautical world has since been content with his description, and has added but little to it. He reported pretty fully upon the *praderias de yerva*, or seaweed meadows, which the *Santa Maria* encountered, and subse-

XUM

quent navigators contented themselves with corroborating his statements, or striving to gain a reputation as ocean explorers, by attributing fresh wonders to the region of Sargasso. The principle underlying the accumulation of such quantities of weed as are met with, is a very simple one. To quote the words of Humboldt, "the waters of the Atlantic between the parallels of 11° and 43° are carried round in a continual whirlpool." Such being the case, drift-weed must of necessity accumulate within the area of the whirl enclosed by the circle of oceanic currents. Finality, as regards knowledge of the Sargasso or weedy sea of the North Atlantic, is yet far from attainment, but much reliable information has been obtained of late years by the researches of German scientists. The captains of the German mercantile marine have been pressed into the service as observers, and the famous *Plankton* expedition has also contributed its quota to swell the stock of reliable information relative to this Sargasso Sea. The ancient belief relative to it was that it was a "muddy, coagulated, dense sea, covered with weed which prevented the advance of a ship." Columbus nowhere affirmed that the weed materially interfered with the navigation of his vessel. Oveido, however, does, and in the hands of subsequent writers the density of the Sargasso increases until it becomes a dense mass, an effective barrier to the passage of ships. This idea is, however, long exploded, and the Sargasso Sea of to-day is simply an area of comparative calm into which drifts the weeds detached by the currents from the shallows over which they flow. This seaweed drift is densest between 70° and 40° West longitude and 20° and 35° North latitude, where the Sargasso may be said to cover the surface of the sea to an extent varying from 10 to 25 per cent. Outside this ellipse is a region where the Sargasso is less abundantly distributed, and outside that again a zone marked by the presence of still less floating weed, until to the north of the fiftieth parallel of latitude the weed ceases to be found. It is remarkable that the main axis of *the* Sargasso proper is identical with that of the region of summer calms, with the exception that the latter is continued farther to the eastward. The sources from which the Sargasso weed is derived has always been a vexed question, but the researches of Dr. O. Krummel, of Berlin, have brought the solution within a more appreciable distance than it has ever been before. The *Plankton* expedition of 1889 threw much light on the matter.

The main supplies of the *Fucus natans* of Linnæus are now pretty accurately determined. The science of sea botany has discovered that a portion of the Sargasso weed comes from the shores of the Caribbean Sea and the West Indian Islands. Other supplies are torn from the confines of the Gulf of Mexico, while some of the weed found floating in Mid-Atlantic has been identified with species attached to the shores of the north of Brazil. That the eastern shores of America produced the weed of the Sargasso Sea was long doubted. Columbus, it is said, was afraid lest the weed should mask some sunken rock, upon which his ships might strike. Others maintained that the "social weed" grew at the bed of the sea, even where the ocean was deep, and that after fructification it easily became detached from the rocks and rose to the surface. The experiments of Bouguers relative to the intensity of the light, which penetrated to a depth of 200 feet below the sea surface, were held to dispose of this theory, because the absence of sunlight in the depths of the sea was held incompatible with the existence of any but *bleached* vegetation. The species of marine weed known as *Laminaria pyrifera* has frequently been found to possess a stem over 850 feet in length.

The amount of weed discernible in any part of the North Atlantic varies with the season. Northward from 45° the scattered weed is only encountered in the late summer and autumn, while it fails completely in the spring. The further we go to the south the greater is the mean annual quantity of weed observed, and the increase is pretty equally divided between the seasons. Near 30° N. the maximum of weed is encountered in the winter, while to the southward of 25° the densest season is spring. These facts prove pretty conclusively that the Sargasso floats in summer time from the current of the Gulf Stream in a south-easterly direction. The rate which this drifting weed assumes in travelling along the convolutions of its course, until it becomes merged in the region of densest Sargasso, varies considerably according to its distance from the coast of Florida. Supposing a bunch of weeds were detached, say, from the Bahama Reef, it would require a fortnight in which to make the journey to Cape Hatteras. The next portion of its voyage—north-east, to the sixtieth degree of west longitude—would be accomplished at about half the speed, and would occupy a month to perform. From 60° W. to 40° W. the speed would have fallen to half-a-knot per hour, and the 950 knots would take ten or eleven weeks to traverse. From this point there are approximately 600 knots to be covered by the now heavy and saturated weed before the south of the Azores is reached. The weed now moves at the rate of seven or eight miles per day. When this point is reached the weed moves still more sluggishly, and gradually becomes merged in the dense Sargasso, where its only motion is an undulatory one, produced by the motions of the Atlantic swell. How long the floating weed encountered in the centre of the Sargasso Sea remains upon the surface is not known, but much of it when it takes up its position there is extremely water-logged, and soon sinks to the bed of the sea, to make room for fresh supplies of fucus.

Such is a brief summary of our present knowledge of the current system of the North Atlantic. It is far from perfect, and will probably continue to be so until the observing powers of the average British shipmaster are more scientifically developed than they are at present.

THE FACE OF THE SKY FOR AUGUST.

By HERBERT SADLER, F.R.A.S.

GROUPS of sunspots of considerable magnitude continue to diversify the solar surface. The following are conveniently observable minima of Algol: August 9th, 11h. 26m. P.M.; August 12th, 8h. 16m. P.M.

Mercury is too near the Sun to be conveniently observed in August, being in inferior conjunction on the 26th.

Venus is a most conspicuous object in the morning sky, and is at her greatest brilliancy on the 15th, more than three times as bright as she will be at the end of the year. She rises on the 1st at 2h. 28m. A.M., or 1h. 58m. before the Sun, with a northern declination of 16° 46′, and an apparent diameter of 46″, about $\frac{15}{100}$ths of the disc being illuminated. On the 12th she rises at 1h. 50m. A.M., or 2h. 33m. before sunrise, with an apparent diameter of 38½″, and a northern declination of 17° 11′, exactly one quarter of the disc being illuminated. On the 31st she rises at 1h. 24m. A.M., or 3h. 49m. before the Sun, with a northern declination of 17° 26′, and an apparent diameter of 29¼″, just four-tenths of the disc being illuminated. About the time of the planet's rising on the 11th an 8½ magnitude star will be about 1′ north of Venus, and on the morning

of the 27th a 9th magnitude star will be seen very near the planet. During the month Venus pursues a direct path through Gemini, without approaching any conspicuous star very closely.

Mars is an evening star, and but for his very great southern declination would be admirably placed for observation, coming as he does into opposition (the most favourable one since 1877) with the Sun on the 4th. He is at his greatest brilliancy on the 6th, when he is distant from the earth about 35,054,000 miles. He rises on the 1st at 8h. 42m. P.M., or 47 minutes after sunset, with a southern declination of 23° 22′, and an apparent diameter of 24¾″. On the 12th he rises at 7h. 43m. P.M., or 17 minutes after sunset, with a southern declination of 24° 13′, and an apparent diameter of 24¾″. On the 31st he rises at 6h. 15m. P.M., with a southern declination of 24° 19′, and an apparent diameter of 22¼″. During the month he describes a retrograde path in Capricornus.

Jupiter is an evening star, and is getting well situated for observation. He rises on the 1st at 10h. 4m. P.M., with a northern declination of 8° 15′, and an apparent equatorial diameter of 42½″. On the 31st he rises at 8h. 5m. P.M., with a northern declination of 8° 3′, and an apparent equatorial diameter of 46½″. The following phenomena of the satellites occur before midnight while Jupiter is more than 8° above and the Sun 8° below the horizon. An eclipse disappearance of the third satellite at 11h. 28m. 49s. on the 1st. An occultation reappearance of the first satellite at 11h. 31m. P.M. on the 3rd. A transit ingress of the shadow of the third satellite at 10h. 39m. P.M. on the 7th. An occultation reappearance of the second satellite at 10h. 48m. P.M. on the 9th. A transit egress of the first satellite at 10h. 40m. P.M. on the 11th. A transit ingress of the third satellite at 11h. 1m. P.M. on the 12th. An eclipse disappearance of the first satellite at 11h. 47m. 57s. P.M. on the 17th. A transit ingress of the first satellite at 10h. 17m. P.M. on the 18th, and a transit egress of its shadow two minutes later. An eclipse disappearance of the second satellite at 10h. 57m. 6s. P.M. on the 23rd. A transit egress of the second satellite at 9h. 52m. P.M. on the 25th, and a transit ingress of the shadow of the first satellite at 10h. 59m. P.M. An occultation reappearance of the first satellite at 11h. 26m. P.M. on the 26th. An occultation reappearance of the third satellite at 9h. 39m. P.M. on the 30th. During the month Jupiter is almost stationary on the borders of Pisces and Aries.

Neither Saturn, Uranus, or Neptune are favourably placed for observation by the amateur.

This month is one of the most favourable ones for observing shooting stars in. The most noted shower is that of the *Perseids*, with a radiant point at the maximum display on August 10th in R.A. 11h. 52m., decl. + 56°. Observations of this region of the heavens with an opera glass will no doubt show stationary meteors, or meteors which shift their positions very slowly. Their place, and the direction of their shift, should be noted for the purpose of determining whether the radiant is a geometrical point, or a circle, or an elliptic area, as suggested with regard to the November meteors (*Monthly Notices of the R.A.S.*, vol. xlvii., pp. 69-73). The radiant point souths at 5h. 37m. A.M.

The Moon is full at 11h. 57m. A.M. on the 8th; enters her last quarter at 6h. 37m. A.M. on the 15th; is new at 10h. 59m. A.M. on the 22nd; and enters her first quarter at 1h. 29m. P.M. on the 30th. She is in perigree at 10h. 5m. A.M. on the 12th (distance from the earth 228,510 miles), and is in apogee at 1h. 3m. A.M. on the 28th (distance from the earth 251,536 miles). The greatest eastern libration takes place at 2h. 40m. P.M. on the 6th, and the greatest western at 5h. 13m. P.M. on the 20th.

Chess Column.

By C. D. Locock, B.A.Oxon.

All communications for this column should be addressed to the "Chess Editor, *Knowledge Office*," and posted before the 10th of each month.

Solution of July Problem (by J. Juchly, Munich).

Key-move, Kt × P.

If 1. . . . B to K4, 2. Q to R8, &c.

If 1. . . . Anything else, 2. Q to Qsq, &c.

There are excellent "tries" by 1. Kt to B7, B to K4! and 1. Q to Qsq, B to B5!

Correct Solution received from Alpha, who has appreciated the points of the problem.

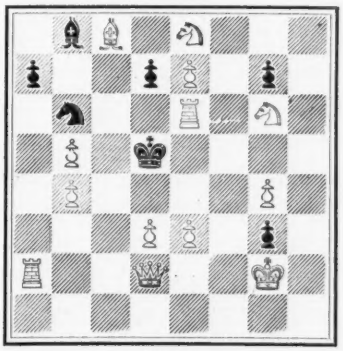
Betula.—Your problem has been carefully preserved for a solution tourney, which seems still distant.

A.B.S.—Too late to notice further. This column goes to press about the middle of the month.

PROBLEM.

By D. R.

Black.



White.

White to play, and mate in two moves.

The following game was played in the National Tournament of the British Chess Association, March, 1892.

"Ruy Lopez."

White (C. D. Locock).	Black (Jas. Mason).
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to Kt5	3. Kt to B3
4. Castles	4. B to K2
5. P to Q4 (*a*)	5. Kt takes KP
6. Q to K2	6. Kt to Q3
7. B takes Kt	7. KtP takes B
8. P takes P	8. Kt to Kt2
9. Kt to Q4	9. Castles
10. R to Qsq (*b*)	10. Q to Ksq
11. R to Ksq !	11. B to B4 (*c*)
12. Kt to Kt3	12. B to Kt3
13. Kt to B3	13. P to Q4 (*d*)
14. P takes P *en pass.*	14. Q takes Q
15. R takes Q	15. P takes P
16. B to B4	16. B to K3
17. Kt to R4	17. KR to Ksq (*e*)
18. Kt takes B	18. P takes Kt
19. Kt to Q4	19. B to Q2
20. R takes Rch	20. R takes R

21. B to K3 (*f*)	21. P to QB4
22. Kt to K2	22. P to Q4
23. P to QB3	23. B to B3
24. R to Qsq	24. R to Qsq (*g*)
25. Kt to B4	25. P to B3
26. P to QKt4	26. K to B2
27. P takes P	27. P takes P
28. P to B3	28. P to Kt4 (*h*)
29. Kt to Q3	29. P to Q5
30. P takes P	30. P takes P
31. B takes KtP (*i*)	31. R to KKtsq (*j*)
32. R to QBsq!	32. B takes P
33. R to B7ch (*k*)	33. K to K3
34. P takes B	34. R takes Bch
35. K to B2	35. Kt to Q3
36. R takes P	36. R to QR4
37. P to QR4	37. Kt to B4
38. R to QKt7 (*l*)	38. R to Rsq
39. Kt to B4ch	39. K to K4
40. Kt to Q3ch	40. K to K3 (*m*)
Drawn Game (*n*)	

NOTES.

(*a*) 5. Kt to B3, compelling P to Q3, is also good. White wished, however, to bring about a familiar variation in order to test the position arising from his 11th move.

(*b*) Probably as good as anything at this stage, provided that it is followed up as in the text. 10. QKt to B3 followed, if Black replies 10. . . . Kt to B4, by 11. R to Ksq is the usual line of play, from which White certainly derives no advantage. Black's reply is forced.

(*c*) The correct reply, as Mr. Steinitz points out. If instead 11. . . . Kt to B4; 12. Kt to B5, Kt to K3; 13. Q to Kt4, P to KB3?; 14. B to R6! followed by 15. B × P! wins (Bauer *v.* Porges).

(*d*) Safer than 13. . . . P to B3; 14. Q to B4ch, K to Rsq; 15. B to B4: or 14. . . . Q to B2, 15. P to K6! with a fine game. White takes in passing in order to get rid of the majority of Black Pawns on the Queen's wing. 14. Kt to R4 was the alternative.

(*e*) White's last move was a necessary preliminary to the contemplated R to Qsq. Black cannot well preserve the Bishop, for if he retires to B2 then 18. Kt to B5!; or if to Qsq, then 18. R to Qsq, with the better game.

(*f*) To prevent R to K7 after the Knight is driven away. The game is now even, but Black plays to win by advancing the Pawns. As the Pawns have already lost the option of moving either one or two squares, he can hardly do better. White waits their approach with the idea of breaking them up when within reach, reserving for his own Pawns the option of moving two squares.

(*g*) 24. . . . R to Rsq has also something to be said for it.

(*h*) This can hardly be good, but all his pieces are engaged in defence.

(*i*) Tempting though this is, it was not to be ventured without due consideration. The variations in the next note had to be worked out.

(*j*) If, firstly, 31. . . . B to R5, 32. R to QBsq! (not 32. R to Ktsq, Kt to Q3, threatening B to B7) 32. . . . P × B (or B to Kt4) 33. R to B7ch, recovering the piece. Secondly, and perhaps best of all, 31. . . . B × P!, 32. P × B (the Rook dare not leave the Queen's file) 32. . . . P × B with an even game nearly.

(*k*) Better than taking the Bishop at once, as it secures the gain of the RP.

(*l*) A strong move, threatening R to Kt5, when Black must exchange Rooks or lose the Knight.

(*m*) Interesting possibilities result from 40. . . . K to Q4, 41. R to Kt5ch, K to B5; 42. Kt to Kt2ch, K to B6, etc.

(*n*) Against a player less a master of end-game play than Mr. Mason, White might have tried for a win by 41. R to Kt6ch, K to K2; 42. R to Kt4, etc. The attempt would have been both difficult and dangerous.

CHESS INTELLIGENCE.

The Dresden International Tournament began on Monday, July 18th. The entries were eighteen in number, and included Messrs. Blackburne, Loman, and Mason, of London, Dr. Tarrasch, of Nuremberg, M. Winawer, of Warsaw (who is probably rather short of practice), and Herr Walbrodt, of Berlin. Of the last-named player a great deal is expected on the strength of his success in a match with Von Bardeleben, who is also a competitor. The score will be given next month. Gunsberg, Bird, Lasker, and Tschigorin, to mention only European players, are notable absentees, whose place is hardly filled by the host of Austrian and German stars of lesser magnitudes.

An interesting match between Dr. Smith and Mr. T. Block has been in progress lately at the City of London Chess Club. The match is five up, and the score at one time was four to one in Dr. Smith's favour. Mr. Block, however, has since drawn up level, the score at the time of writing being four games to each player.

The City of London Club sent a strong team to Brighton early last month to encounter the Sussex Chess Association, who were defeated by 11½ games to 7½, one game being left unfinished, and, in the absence of the umpire, undecided.

Brighton is also the scene this year of the annual meeting of the Counties' Chess Association, beginning as usual on the first Monday in August, and concluding on the following Saturday. The programme has been published elsewhere, and it need only be said that the various tournaments for players of various strength are much the same as usual. Play takes place almost all day at the Brighton Pavilion.

Mr. Lasker has made arrangements for an American tour in the autumn. Besides giving exhibitions of simultaneous play, etc., he is willing to contest short matches with the leading Transatlantic players.

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